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Robert Shwartzman, who competed at Le Mans last year as a Ferrari driver, switched to IndyCar with Prema Racing and became the first rookie since Teo Fabi in 1983 to take pole position at the Indy 500

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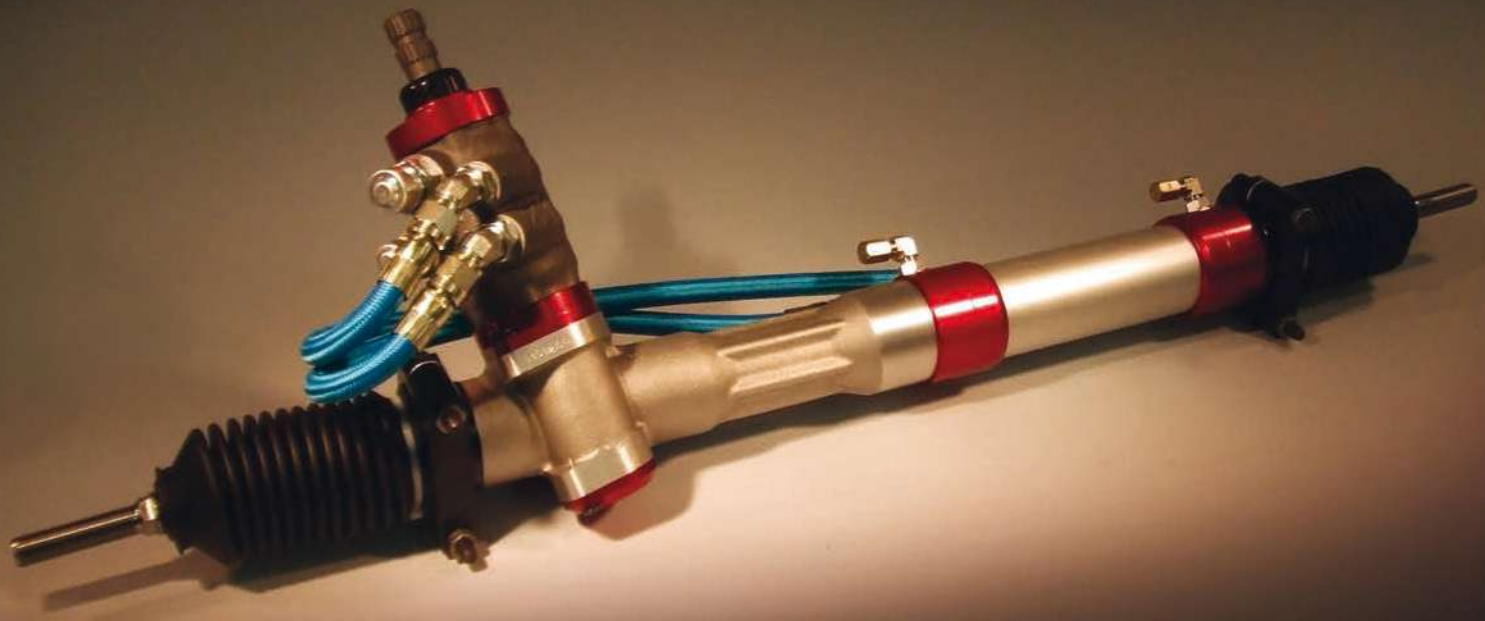

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Tin top dog

The BTCC is one of the world's top touring car series, but how might it evolve?

The British Touring Car Championship is planning to introduce new technical regulations in 2027. It is unlikely to be an overhaul, as the series' chief executive, Alan Gow, has said that evolution rather than revolution is the best way to control costs and maintain a level playing field. That is a logical direction to take, considering the NGTC formula has been around since 2011 and has typically produced very close racing that has kept fans flowing through the gates of British circuits, and watching on free-to-air TV at home.

However, to ensure the good times last, the BTCC needs to take care of its future grid, as well as the current one. Adopting technologies that don't alienate the teams, while also achieving sustainability aims and ensuring recognisable car brands remain on the front of bonnets, is a tough balance for the series to strike.

Engine formula

Currently, the BTCC has seven different car brands represented. Four of those– BMW, Ford, Hyundai and Toyota – supply their own engines, albeit built and developed by specialist tuners. The rest use a standard powerplant from M-Sport. All engines are built to the same 2.0-litre, inline four, turbocharged specification. But what might the future of this engine formula look like? Engine downsizing is an ongoing trend among automotive manufacturers as they pursue efficiency gains, so I posed the question to BTCC technical director, Sam Riches, at the start of the 2025 season. One of his suggestions was for TOCA, the championship's governing body responsible for writing the rules, to preserve the 2.0-litre arrangement in a way that stops it relying on a shrinking number of OEMs to licence their own. An idea for the longer term could be to have a base product that each engine builder individually tunes, maybe with the same cylinder head, pistons, sump and connecting rods, but with a handful of free items, such as the valvetrain and camshaft profile, for engineers to play with.

'That's still a way off, and I'm not sure that's ultimately the right answer,' stressed Riches. 'At the moment, our teams are relatively happy and have supply of their base engines sorted for the foreseeable future.'

Of course, there may come a point in the future when they don't. For that, TOCA needs a plan. Money is the main topic of discussion in the BTCC paddock, and the governing body's priority is to avoid soaring engine costs. TOCA reckons that following the road car trend of smaller capacity (under 2.0-litre) engines and then developing them to produce 400bhp is going to be very expensive. That's a surefire way of giving the car brands cold feet.

The BTCC considers itself a standard setter for UK motorsport when it comes to implementing sustainable powertrain technologies. It was the first touring car series in the world to adopt hybrid systems when it rolled out the Cosworth 48V push-to-pass system in 2022. Three seasons later, the hybrid system was consigned to the BTCC history files, having been dropped in favour of 100 per cent sustainable content fuel. The cars are now much lighter and beating lap records around the country.

Switching to sustainable fuel has laid the foundations for the BTCC to keep using internal combustion engines, so electric isn't really being considered; TOCA was put off by the struggles faced by the ambitious, yet unsuccessful, FIA ETCR series. Hydrogen as a fuel is a more realistic alternative direction, if it can be handled safely at the UK's racetracks and doesn't blow competitors' budgets to the point of exodus. One OEM is understood to have been in recent discussions with a team about trialling a hydrogen powertrain in the BTCC. Alternative fuel types have been welcomed in the past, such as diesel and liquefied petroleum gas (LPG) and the BTCC should continue to be a test bed for emergent technologies, if for no other reason than to identify what works and what doesn't.

Styling ahead

There is also the question of what BTCC cars of the future will look like. This year, the leading touring car championships in Brazil and Argentina switched to SUV-style bodywork. NASCAR is exploring similar body styling, as seen on its recent electric demonstration vehicle. Could the BTCC go a similar way? Like it or not, SUVs are increasingly common on British roads and it's only a matter of time before OEMs want to promote them on track.

The BTCC has never shied away from cars that look different. The amazing Volvo 850 Estate helped establish a 1990's automotive cultural icon. In 2014, Team Dynamics introduced the NGTC-spec Honda Civic Tourer, which looked like it had spent a few hours on a medieval rack. To lovers of diverse grids like me, permitting SUV-style cars to race alongside the current C-segments and hatchbacks would be top-drawer entertainment. For a series with such a large fan base, that optical entertainment factor is arguably more important than what's under the bonnet.

Danny Dzenis / dd-photography

Touring cars are a hugely popular form of motorsport, with strong manufacturer backing and loyal fan bases around the world that are happy to accept diverse and interesting concepts

The BTCC should continue to be a test bed for emergent technologies, if for no other reason than to identify what works and what doesn't

Wind of change

F1's 2026 engine regulations were announced three years ago, yet just a few months before the start of the new era, doubts are still being expressed

By CHRISTIAN MENATH

Bernie Ecclestone, the former ringmaster of Formula 1, was not that complimentary about the new hybrid engine rules when they were introduced in 2014. At the time, the new 1.6-litre, V6 power units were a thorn in the impresario's side. They were too quiet, too expensive and too complex, and he campaigned long and hard to not introduce them. Some of those problems remain unresolved to this day, but in true Formula 1 fashion, after lots of complaints the paddock has come to terms with them.

Now though, after 12 years, the current power units will be replaced by a new generation of engines in 2026, introducing a whole raft of fresh debates and concerns.

Stefano Domenicali, Ecclestone's successor, will never be as critical of the proposed new regulations as Ecclestone. F1 has become a marketing monster; all those involved have come to realise it is bad for their own wallets to be so publicly frank. CEO of the Mercedes F1 team, Toto Wolff, makes no secret of this fact: 'We should be excited about these new regulations coming in next year,' he says. 'We should be talking them up. This is our sport. It is important to have the positivity about it that such an exciting motor comes into the car.'

However, the fear of a failed engine revolution is becoming increasingly prevalent as 2026 approaches.

The details of the new powertrain formula have already been covered in *RE* V34N5, but a quick re-cap of the framework is as follows: the 1.6-litre, V6, turbocharged engine remains almost unchanged. Details such as boost pressure and compression ratio have been tweaked, but the architecture remains identical.

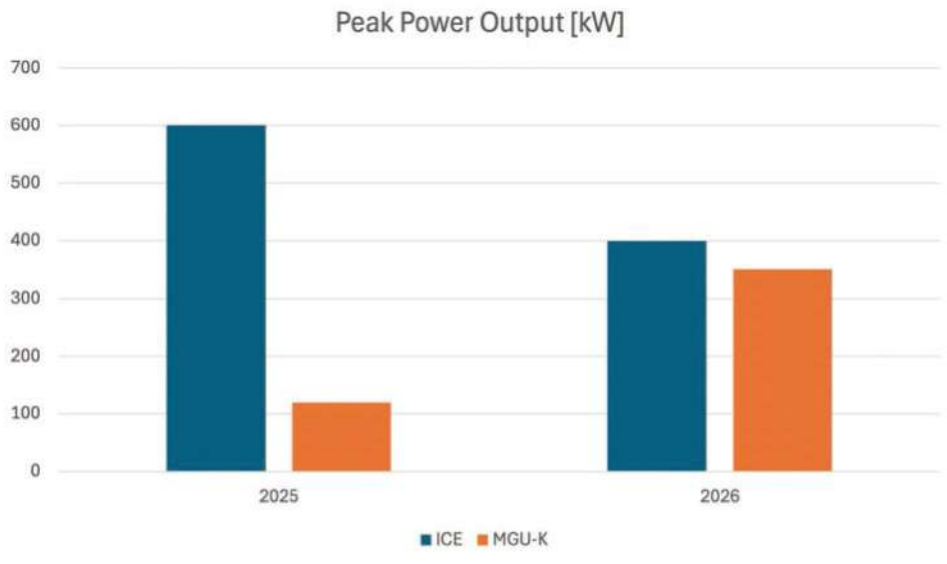
FIA

Management of the available energy is one of the ongoing talking points regarding the 2026 regulations, which are fast approaching

'We should be excited about these new regulations coming in next year. We should be talking them up'

Toto Wolff, CEO of Mercedes F1 team

It is widely known that the 2026 chassis regulations are a consequence of changes made to the engine formula



Christian Menath

The difference in proportional power between the ICE and MGU-K from the current cars to 2026. Note that the ICE maximum power values shown are estimated, considering there is no upper limit in the regulations

There are, however, three key differences, agreed in 2022 after lengthy negotiations to attract new manufacturers (which has been achieved with Audi, Red Bull Powertrains / Ford and the Honda comeback). General Motors will also come with its own engine for the Cadillac team in 2029. The delayed withdrawal of Renault could probably not have been prevented by any set of regulations in the world.

The most significant of the differences is there will no longer be an MGU-H, the motor generator unit that plugs the turbo lag at low revs and uses heat energy at higher revs to generate electrical energy. Secondly, the MGU-K will become more powerful. This electric motor can currently put 120kW onto the crankshaft, but from 2026 it will produce an impressive 350kW. Thirdly, the fuel flow rate will be drastically reduced.

Presently, a maximum of 100kg/h can be injected at 10,500rpm, while in the future this will be regulated by energy amount. 3000MJ/h may be injected. With a lower heating volume of between 38 and 41MJ/h, which the regulations prescribe for the new 100 per cent sustainable fuel, this corresponds to a fuel flow of 73-79 kg/h, so a reduction of more than 20 per cent compared to the current engine.

Energy balance?

At the same time, various simplifications will make the ICE slightly less efficient. As a result, its output will be reduced by around a quarter. The FIA predicts a figure of close to 400kW, which means an increase in the proportion of electric power from the system of around 47 per cent. This is precisely where the engine's major defect lies.

In order not to exacerbate the obesity of modern F1 cars, the battery capacity of 4MJ has been retained. But because the power density is increasing considerably due to the increased MGU-K power, battery weight will rise by at least 10kg to 35kg in 2026. However, this is the least of the problems at this point.

The biggest issue with the new power unit is the energy balance. On a fast lap, it should not be too much of a concern. Normally, 8.5MJ can be recuperated per lap and, with a fully charged battery at the start of a qualifying effort, 12.5MJ are ideally available. This is enough for almost 36 seconds of boost with the full 350kW contribution of the MGU-K. So, the length of boost is comparable with the existing power units.

Currently, the 120kW electric boost can be fed from the battery for 33.3 seconds per lap, but there is also unlimited energy available directly from the MGU-H. This will not be the case in 2026 when the MGU-H disappears.

Here's the issue though: while the current engines only lack 120kW when the battery is empty, next year it will be 350kW. And the combustion engine will be weaker, too. So, while there is still a good 600kW with an empty battery today, by 2026 there will only be 400kW. Yes, the available electrical energy could be utilised differently, but that makes no sense. As soon as the traction allows it, you boost. To optimise lap time, maximum power is called upon at the start of the straight.

In race trim, the problem becomes greater still. There, the energy must be balanced on average. This means that only a maximum of 8.5MJ is available, enough for 24 seconds of maximum boost. And because F1 only recuperates via the crankshaft at the rear axle, it is difficult to get back even this much energy over one lap on some circuits.

Meanwhile, charging the battery via the ICE has been severely restricted. This is why the 8.5MJ is only available in 'normal cases'. Exceptionally, the limit may be reduced to 8MJ at circuits where the FIA determines that the maximum possible energy harvested per lap under braking and in partial load is less than that figure. It's worth noting the original value per lap was actually 9MJ.

Chassis modes

This is just one of many adjustments to the energy management. It is widely known that the 2026 chassis regulations are a consequence of changes made to the engine formula. Narrower cars and tyres will reduce the frontal area, while active aerodynamic parts will improve aero efficiency. On the straights, the cars switch to X-Mode. There, the front and rear wings are set flat to reduce drag. Then, before the corner, the flaps fold up again and the Z-mode becomes active, offering plenty of downforce. All this has been developed to counteract the reduction in energy, because when the battery is empty and only the ICE is pushing on the straights, low drag is essential.

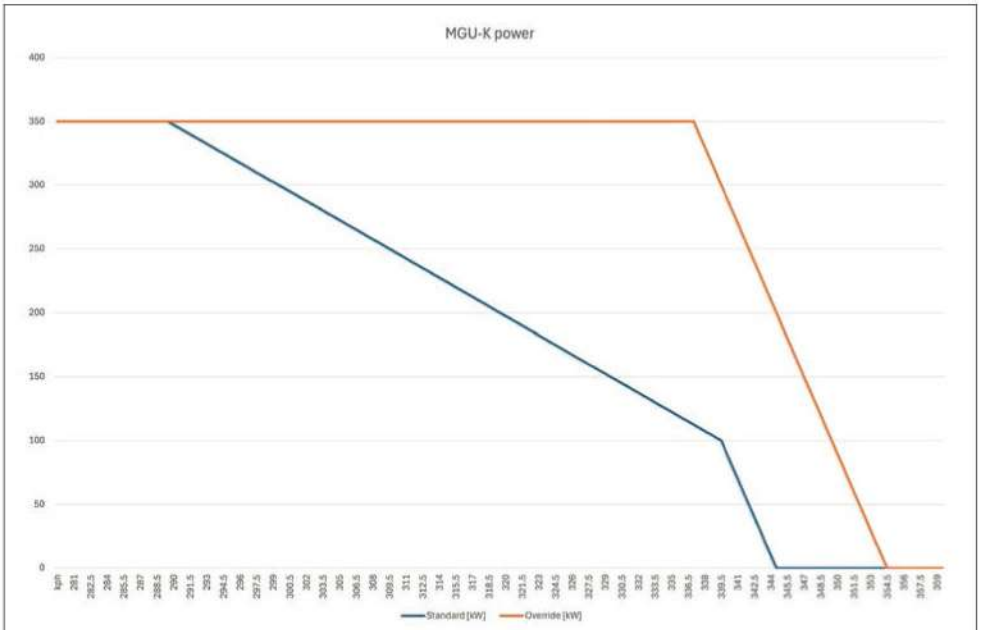
The chassis regulations have been widely criticised. The tenor of the criticism is that the chassis side of the equation is having to deal with problems the engine side has caused. Some believe the wrong end of the horse has been tethered to the cart, and that instead of finding an overall vehicle concept, those in charge have focused too much on the engines in order to attract new manufacturers. Behind closed doors, even public supporters of the rules admit this.

The adjustments to the chassis regulations are understandable, but they are not enough. That is why an energy management working group has been trying for some time to optimise the power units. Numerous remedies have already made it into the rules.

There was another reason for reducing the recuperated energy from 9MJ to 8.5MJ. This was because some more room was needed to incorporate an overtaking aid. DRS is no longer available due to the presence of X-Mode and Z-Mode. That's why there will be a driver-operated override mode for the power unit in 2026. On the one hand, this will allow the driver behind to recuperate more energy per lap. How much depends on the track, but the maximum is 0.5MJ.

On the other hand, the chasing driver is allowed to expend their e-power for longer. In order to avoid exorbitantly high speeds,

Christian Menath



The rate at which the MGU-K's contribution slows depends on whether or not the car is in override mode

'Inevitably, the chassis designers will outperform the criteria of the regulations, and a consequence of that will be the amount of lift-and-coast there will be in a grand prix'

Christian Horner, Red Bull F1 team principal

the MGU-K must not constantly push with 350kW. From 290km/h, the power reduces linearly to 100kW up to 340km/h. Between 340 and 345km/h, the maximum e-power decreases linearly from 100kW to zero. However, the situation is different when the cars are in override mode. Here, the full 350kW can be boosted up to 337.5km/h. The MGU-K power is then reduced linearly from this speed to zero kW at 355km/h.

Protective mechanism

There is also another protective mechanism in place. To prevent the energy from being output too unevenly, the e-power must be reduced slowly, as a sudden loss of 350kW of system power could clearly lead to dangerous situations on track. The driver's maximum power demand must therefore not reduce at any rate greater than 50kW in a one-second period at races where the FIA determines that the power limited distance exceeds 3500m, and 100kW in a one-second period at all other races. This is intended to prevent sudden differences in speed between the cars, while ensuring energy is not completely spent at the start of a straight.

Red Bull's Christian Horner warned of 'Frankenstein' cars two years ago; the relationship between the power unit and chassis rules remains under heavy scrutiny

This is all well and good, but it's a far cry from solving all the problems. Most recently, a proposal in a Formula 1 Commission meeting to reduce the maximum power of the MGU-K to 200kW during the race caused a great deal of anger. Though Red Bull publicly backed the proposal, it's worth recalling what its team principal, Christian Horner, warned two years ago: 'I think that perhaps where we need to pay urgent attention before it's too late, is to look at the ratio between combustion power and electrical power to ensure we're not creating a technical Frankenstein, which will require the chassis to compensate to such a degree with movable aero and to reduce the drag to such a level that the racing will be affected.'

Compared to Ecclestone's statements a decade ago, Horner's comments are subtle criticism, but the Briton is one of few to have publicly criticised the 2026 engine rules. It is already too late to turn off the tap. The engines have been developed, though adjustments can still be made to energy management. Nevertheless, the 200kW proposal has not met with universal approval. 'Reading the agenda of the F1 Commission is almost as hilarious as reading some of the comments I see on Twitter on American politics. I really want to protect ourselves and make no comment, but it's a joke,' was Wolff's take on the matter.

Power reduction?

FIA single seater director, Nikolas Tombazis, one of the architects of the regulations, seemed to like the proposal. In the F1 Commission, he presented the effects of such an e-power reduction in the race with different speed profiles for three circuits with different energy demands. While the lap time simulations did not show any blatantly slow times in the adjusted race trim, the critics remained unconvinced.

Those in favour of the change argue that the FIA could also use safety arguments to push through the changes, but the federation does not want to do this. At the moment, changes to the regulations require a super majority. So, in addition to the organisers, this would require approval by 65 per cent of the power unit manufacturers. Currently, Ferrari remains open minded, but Mercedes, Honda and Audi are all unenthusiastic about the proposal. There is also a school of thought that believes Red Bull and Ferrari do not want to change the regulations in the interests of the sport, but in their own interests.

'Obviously, the closer you come to new regulations, the more people act – all of us – in the interest of the team, that's their duty,' notes Wolff.

Theoretically, a reduction of electrical power in the race would be simple and could be regulated via software. But then the battery, MGU-K and cooling system could have been designed differently during development. Delivering 350kW over a qualifying lap is a different challenge to doing it over an entire race distance.

'The biggest concern is one that is not new, it's one that's been flagged from two years ago by all the PU manufacturers, is the amount of harvesting there is. Inevitably, the chassis designers will outperform the criteria of the regulations, and a consequence of that will be the amount of lift-and-coast there will be in a grand prix,' warns Horner.

More chassis development means higher cornering speeds, and consequently more time spent full throttle with shorter braking zones, yet it is becoming increasingly difficult

to recuperate energy on the brakes, or in the partial load range. In addition, by reducing the MGU-K power in the race, overtaking assistance could also be extended by introducing a push-to-pass system.

'If it's genuinely in the interest of the sport and racing, not to have all this lifting and coasting, then I think it's something that warrants looking at. It doesn't change the spec or output of the engine, it's just the amount of battery deployment, maybe at certain grands prix,' says Horner.

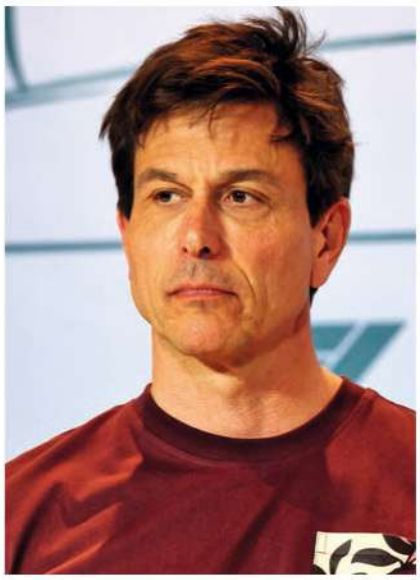
However, the competition does not accept this. For these 'certain grands prix' there is already the route of reducing electrical power slower. However, Mercedes does not want to close the door completely. Wolff: 'Are we going to see energy harvesting disasters in Baku or Monza? I don't know. We hope not. What we've signalled is that, rather than act now based on assumptions – like we've been great at in previous years, and then overshot or undershot – as Christian said, you don't need to throw the hardware away and come up with something new. It's within the software and bandwidth of what you can do. We'll see the final product next year in testing.'

System paralysis

The system is paralysed by the uncertainty of which change could be advantageous or disadvantageous for whom. At Mercedes, hopes are high that the team will have gained an edge on the engine side, like in 2014 when it embarked on a run of eight constructors' titles. Red Bull in particular is wary of this. In 2014, the team was a Renault customer and had no chance of winning against Mercedes, but with Red Bull Powertrains and Ford supplying its 2026 power unit, its fate is in its own hands. However, confidence in its first proprietary drivetrain is not limitless.

That is why Red Bull is also fighting for a relaxation of the homologation guidelines. There is already a complete homologation timetable in the regulations, which defines exactly which components must be frozen in development, and when, but no one at the power unit manufacturers is really happy with this. The reason for doing so is the FIA wants to keep costs under control, so the budget cap now also applies to powertrain builders.

With the so-called ADUO (Additional Development and Upgrade Opportunities), there is already a passage in the regulations intended to ensure no manufacturer is left behind. Anyone more than three per cent behind the class leader on the ICE side, according to a complex metric, receives additional development and upgrade capacities. Yet this is not enough for the manufacturers. A development token system, as used at the beginning of the 2014 regulations, is also not favoured, so there is another problem brewing.



Mercedes team principal, Toto Wolff, prefers to wait and see what the 2026 rules will produce on track, rather than making radical changes based on assumptions

When writing the regulations, the FIA took care not to leave too much room in many areas to prevent extreme excesses. Some believe the FIA would like to have complete equality in the engines, and there has already been a proposal to freeze only the leading power unit. But if that happens, why do we even need the diversity of manufacturers? Why not have a spec engine?

In the desperation surrounding the 2026 rules, it even came to the point at the beginning of this year that cancellation was on the cards. After Domenicali and the FIA president, Mohammed Ben Sulayem, had publicly dreamed of a return to naturally aspirated V10 engines, Red Bull sensed a breath of fresh air. Next year's engine regulations will run for five years. The manufacturers have planned to use these engines up to and including 2030, but why wait so long? An interim solution could be to keep the current engine format and then switch to V10 engines in 2028.

But then which engine should Audi bring in 2026? And what will become of the Aston Martin-Honda works team? The FIA quickly made it clear that no team or manufacturer would be prevented from participating by a change to the engine formula. Accordingly, a key meeting about 2026 held in Bahrain, which was attended in person by Audi CEO, Gernot Döllner, and other high-profile OEM bosses remotely, lasted just 70 minutes. On the one hand, the political situation was too tricky. On the other hand, at least Mercedes, Audi and Honda had no interest in a change.

The 2026 regulations governing power unit and chassis have achieved what they set out to do – attract new power unit manufacturers to the sport, leading to the FIA publicly stating, 'Underlining that for the 2026 cycle, the correct technical path has been chosen.' However, the fact the meeting in Bahrain took place at all is already a sign of doubt.

For independent engine manufacturers, an F1 engine like this will never become a business case, so it will remain a manufacturer sport that does not have to be financially profitable

While F1 and the FIA have respect for the 2026 regulations, the former fears for its product. A repeat of the beginning of the turbo-hybrid era, with a team that has dominated for so long, would be bad for business. There is also a big question mark over energy-saving racing.

Understandably, the FIA fears any negative effects on the competition. Ben Sulayem has said he wants to put the cars on a diet to make them more agile again, yet the 2026 engines, which are already heavy today, will weigh an additional 34kg. The teams are now trying to work out how they can achieve the new minimum vehicle weight, which is 30kg less than the current one.

United front

However, the most important argument unites almost all of them: money. Even with a budget cap and numerous cost reductions, F1 power units remain immensely expensive. Red Bull can now see in black and white exactly how much it costs to develop and build its own. At the same time, the budget cap has given the team a taste for how nice it feels to earn money with Formula 1. For independent engine manufacturers, an F1 engine like this will never become a business case, so it will remain a manufacturer sport that does not have to be financially profitable.

Yet that's exactly what F1 and the FIA are afraid of. They still remember how the manufacturers dropped out during the global financial crisis and want to protect themselves from a repeat of that scenario. 'We need to take these protective measures while the sun is shining, and not when it starts raining. The drive to cut costs is important to consider,' Tombazis admits.

The 2026 power unit remains a problem. The fact that serious adjustments are still being discussed months before its introduction, before even the first metre has been covered in a new car, and that many of those involved were even thinking about scrapping it completely, is the modern-day epitome of Ecclestone's 'Formula 1 is crap' comment. The fear is real.

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Reaching the milestone of having fully sustainable racing fuel was a major breakthrough for TotalEnergies

Spring into action

TotalEnergies hasn't stopped developing advanced fuels since rolling out a 100 per cent sustainable solution in 2022. That served it well when the WRC came calling

By JAMES NEWBOLD

Four years is a long time in motorsport. That's especially true when it comes to sustainability advances in fuel since 2021. When TotalEnergies ceased to supply its control Excellium Rally blend to the FIA World Rally Championship (WRC) at the end of that season, it had a renewable content of just 10 per cent. During the intervening years, the move away from petrol to fully sustainable fuel has become an increasingly common theme, although Formula 1 will be somewhat late to the party in 2026.

So much so, it has virtually ceased to be a topic of conversation in the FIA World Endurance Championship, which began its journey with TotalEnergies' Excellium Racing 100 product, derived completely from renewable biomass, including vineyard residues, in 2022. The WRC, too, has shunned fossil fuels during the same period.

It would be a mistake to assume that, just because fully sustainable status has been reached, the fuel development process is nearing its end

However, it would be a mistake to assume that, just because fully sustainable status has been reached, the fuel development process is nearing its end. Although increasingly attention is being placed on hydrogen, which WEC co-organiser, the Automobile Club de l'Ouest (ACO), has committed to adopting at the 24 Hours of Le Mans in the not-too-distant future, it is a longer-term work in progress that is likely to rival, not replace sustainable fuel. At time of writing, the first competitors racing with hydrogen in the WEC aren't slated to arrive until 2030 and, even then, only at selected races.

Room to grow

The work involved in TotalEnergies reaching the 100 per cent sustainable milestone with its bioethanol-based Excellium Racing 100 certainly should not be underestimated.

'You don't shoot [ideas] everywhere… You have to follow a path, have a structure, and [take] small steps. So far, this strategy has taken us to the place we wanted to be'

Thomas Fritsch, technical competition manager at TotalEnergies

TotalEnergies

Technical competition manager, Thomas Fritsch, is keen to see TotalEnergies further reduce its carbon output

Not very long ago, it would have been fanciful to imagine internal combustion engines not being hand-in-glove with fossil fuels. Thomas Fritsch, TotalEnergies' technical competition manager, admits to having been 'a bit worried about what could happen' when its first few Excellium Racing 100 formulations were dyno tested. But it was with confidence that the fuel was given a debut in the 2022 WEC season opener at Sebring.

'When you do this development, you have to go big,' says Fritsch. 'If you do some good testing, you are confident of the tests you've done, then you think let's jump into the big championships. I'm not going to say it was easy to go from 10 to 100 [per cent] the first time, but we *had* to do it, and I think we made a good choice.

'The 24 Hours of Le Mans was the biggest test bench we can dream of. You have so many different engines competing and the test duration is huge so, once you proved your technology [there], you're more confident to make the small adjustments and develop a bit more.'

The fuel, which reduces greenhouse gas emissions from track vehicles by at least 65 per cent relative to fossil fuel equivalents, is now widely used across endurance categories in Europe and Asia. It has also been adopted in the Superbike World Championship-supporting Yamaha R3 bLU cRU World Cup.

Fritsch explains that it is designed 'to be compliant with the FIA regulation to be [saving] at least 65 [per cent]', a figure based on the latest updates to the European Renewable Energy Directive (RED) in 2023.

Smaller steps

Further significant reductions in carbon output, inching towards zero emissions, is therefore a big ask, not least because motorsport is only a modestly-sized area of focus for TotalEnergies. 'Our sustainable racing fuel is not comparable in terms of volumes to regular fuel,' notes Fritsch. Re-inventing the wheel on good practice production techniques, that are already well proven in the industrial world, would therefore be ill advised at this juncture.

'When you make this calculation [of a 65 per cent reduction], it takes into account all the steps of the fuel production process,' explains Fritsch. 'To reduce as much as possible, you have to use industrial processes that are already well developed and optimised for CO_2 reduction.'

Progressive iterations that yield small gains is the form developments are now most likely to take. 'You don't shoot [ideas] everywhere, go right, go left,' says Fritsch. 'You have to follow a path, have a structure, and [take] small steps. So far, this strategy has taken us to the place we wanted to be.'

TotalEnergies

TotalEnergies supplies its fully sustainable Excellium Racing 100 fuel to numerous categories around the globe, including the FIA World Endurance Championship

So, while a similarly significant breakthrough to TotalEnergies' 2022 feat may be difficult, Fritsch reckons there is every reason to expect more progress to be made in carbon output reduction.

'Maybe in a few years we find some better technologies and we'll have to do it again,' he says. 'If you go 30 years back in fuel development, when you have small numbers of molecules, you had a lot of room to work on performance and consumption, and it's a bit like the situation we're now living in.

'The number of molecules accessible with sustainable commitment is way lower than with the fossil one, so we have to test new blends. It's a bit like we took a few steps backwards to make a bigger jump, and now it's real fuel development work again; like finding more performance, less consumption. We have a bit more room to improve the fuel than we had in the past with the fossil fuels, where we were really at the top end already.'

Behind the scenes

It's still early days for the new RRX AS formulation TotalEnergies began to supply WRC manufacturers with in April 2025 (see sidebar on p84). but the fact it exists at all demonstrates the French company's desire to keep the ball rolling after marking its centenary in 2024.

TotalEnergies

Engineers at TotalEnergies believe the company has more room to improve fully sustainable fuel than was possible with the already highly developed fossil fuel blends they are replacing

M-Sport

TotalEnergies' new RRX AS formulation made its debut in the World Rally Championship's Rally Islas Canarias round in April

TotalEnergies

Currently, renewable fuel is predominantly used by the aviation industry, and production is focused on where demand is greatest

Work began on the new, fully sustainable blend two years ago, with a view to using it in national events. Utilising waste and residues from the circular economy, with the same philosophy as Excellium Racing 100, it was designed specifically to meet the demands of rally competitions in a manner that isn't possible with endurance racing. Where the long-distance discipline puts a high premium on reliability and consumption, rallying involves numerous shorter stages split by longer road sections and engine types that are less varied than in the WEC.

'In rally, you have only the inline four [cylinder] turbocharged engines, so you can concentrate on what you know is working for this type of engine and really optimise the fuel formation,' explains Fritsch. 'In endurance, you cannot give any advantage to turbo or non-turbo engine, small or bigger displacement, so it's more of a trade-off.'

There could be no way of knowing it would be used in the WRC so soon, but it was still deemed a worthwhile avenue to explore. 'It's part of our job to maintain a range of fuels available for our customers,' says Fritsch.

Trusted replacement

The urgent need for a trusted replacement when financial strife hit the WRC's existing supplier, P1 Fuels, created an opportunity to give RRX AS a high-profile competition debut.

BMW Motorsport

Assisting partners such as the Automobile Club de l'Ouest (ACO) in its push for net zero goes beyond just providing renewable fuel, it requires a global outlook on all aspects of the sport

Its first outing was on the Rally Islas Canarias, round four of the 2025 WRC season. 'We were very lucky with the timing,' Fritsch acknowledges, 'to have this product almost finished when the issue occurred.'

Securing FIA certification was therefore the biggest hurdle for TotalEnergies overcome.

'We rushed that in a very short time,' reveals Fritsch. The same applied for the first production batch. 'We had to rush the final months. When you have to supply a fuel in three weeks, it's mandatory to take something from the shelf, something already tested.'

Fritsch describes the last-minute preparations for the fuel's WRC premiere, which ultimately ran smoothly, as 'a very stressing situation. It was never done on such a short time, so it was long nights of work, a real challenge.'

That said, when asked if there was ever any consideration of the fuel being trialled in a less conspicuous environment first, Fritsch shakes his head.

TotalEnergies was also fortunate in that it was in a position to scale up RRX AS production. Even if it had wanted to, it would have been difficult to do the same with Excellium Racing 100, had that fuel been needed in short order as a WRC stop gap, for it is still being used in the WEC, which was entering its busiest phase of the season when the WRC supplier change occurred.

'We cannot produce race fuel [in large quantities] like that. Especially for sustainable molecules, you have to resolve your feedstocks one year before'

Thomas Fritsch

'We cannot produce race fuel [in large quantities] like that,' he says. 'Especially for sustainable molecules, you have to resolve your feedstocks one year before, so again we were very lucky to be getting this feedstock a few months before planned, and to be able to rush through the production.'

Push for net zero

Evidently, sustainable fuel development is far from over. So, what is TotalEnergies planning next? Put simply, the answer depends on market forces. This not only concerns development, but also how sustainable fuel production will be upscaled, and the purpose in doing so.

As evidenced by its re-branding from Total in 2021, the company holds that no single power source will prevail over the others. Accordingly, its eggs have been split across multiple baskets in a bid to meet a target of net zero emissions by 2050.

In addition to fuel partnerships (an extension of its deal with the ACO until 2028 was signed last year) and involvement with the ACO on its hydrogen test bed, the Mission H24 programme, TotalEnergies provides the DS Penske FIA Formula E World Championship team with customised electric vehicle fluids and, through subsidiary company Saft, supplies the high-density battery used in Peugeot's 9X8 Le Mans Hypercar.

Then there are the renewable projects the company is involved with outside motorsport, with production of liquified natural gas and power generation through solar, wind and hydro sources all on the agenda.

'Of course there are plans to upscale renewable fuel production,' says Fritsch, 'but first you have to look at what you want to decarbonise.' Fully sustainable fuel, as an alternative to electrification, for example, is an expensive means of decarbonising the automotive sector. No such luxury exists in aviation, though, and Fritsch notes that the global market of sustainable fuel is 'maybe 97-98 per cent oriented' for diesel and jet-type fuels.

'You have to bear in mind the cost effectiveness and the challenge of the technology adaptation for the public client.

Richard Kienberger/Goodyear FIA ETRC

As part of the global movement toward decarbonisation, TotalEnergies fuel is transported to events in trucks that use the same blends seen on track in the FIA European Truck Racing Championship

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'I would say it's not the role of TotalEnergies to choose one energy over another, but to comply with the market and to answer the demand of our clients. Of course, we also have this CO_2 reduction target, so we push to give our clients more sustainable products'

Thomas Fritsch

If you compare it, for example, to air traffic. For them, the only way short term to decarbonise the aeroplanes is to use sustainable aviation fuel, so we will focus the capacity towards the market demand.'

Assisting its partners in achieving their own net zero goals, with the ACO aiming for 2030 and the FIA European Truck Racing Championship (ETRC) targeting 2038, will involve TotalEnergies leveraging every element of its portfolio. That is exemplified by the multi-energy strategy adopted alongside the ACO in its Race to 2030 programme. The project aims to reduce the organisation's CO_2 emissions by 30 per cent, with carbon capture projects accounting for the other 70 per cent.

Global view

'We're not only decarbonising the [24-hour] race, we're also trying to get more sustainability in the overall circuit,' says Fritsch. 'We're putting solar panels on top of the permanent racetrack buildings, doing some carbon footprint audits to optimise the ACO's CO_2 consumption and putting an electric recharge station on the racetrack. It's a global involvement.'

This also includes efforts made away from the track, notably in logistics. TotalEnergies has committed to transporting fuel to events in trucks that use the same 100 per cent renewable hydrotreated vegetable oil (HVO) biodiesel as is used in the ETRC. Reported to reduce carbon emissions by up to 90 per cent over the life cycle of the product, HVO100 has been used in competition since 2021.

'Motorsport is also evolving in this direction, not only for pushing on the cars, on the bikes, but also what goes around it,' adds Fritsch. 'With our partners, we try to go deeper, and to bring them the best technology we can supply.'

One way of doing this is by utilising the same engineers, working across road and racing applications, to maximise technology transfer. 'You cannot just copy and paste from one field to another, but maybe use some percentage of one technology to transfer into the other one,' says Fritsch. 'Of course you have to adapt, but we have an energy demand to answer for specific needs, and the more sustainability we can put in this, we will do it.'

Can a fuel be a better solution than hydrogen then? For TotalEnergies, with a foot firmly in both camps, the argument is moot. 'It's of course a huge development, and it won't be able to switch so fast as with the sustainable fuels, but we will keep working strongly to achieve it,' Fritsch says of efforts to hasten hydrogen's advancement. 'I would say it's not the role of TotalEnergies to choose one energy over another, but to comply with the market and to answer the demand of our clients. Of course, we also have this CO_2 reduction target, so we push to give our clients more sustainable products.'

Whatever the future holds, be it for motorsport or road vehicles, it's clear that sustainable fuel will have a part to play in the net zero end game. The age of racing fuel development is far from over.

WRC return

As the lubricants partner to Citroën during its spell of dominance, and the sole fuel supplier from 2019-'21, TotalEnergies is no stranger to the FIA World Rally Championship. However, its sudden return to the service park in April 2025 was not foreseen. The demise of previous supplier, P1 Fuels, falling into administration in February, caught teams and the FIA on the hop.

(M-Sport)

M-Sport's Richard Millener believes it is important to retain sustainable fuel in the World Rally Championship because of the remote locations the series visits

'It has been a hell of a scramble,' relates M-Sport Ford team principal, Richard Millener. 'The engines are mapped to the specific batch of fuel that is produced for the championship, so the minute you change the fuel, you have to re-do all the dyno work.'

The task facing TotalEnergies wasn't lost on Millener, who reveals that M-Sport could only begin the re-mapping process a matter of weeks before the tarmac event by the time its bespoke RRX AS fuel had been delivered in the quantities required. In all, over 5000 litres were sent to Spain for use by Rally1 and Rally2 teams. At €8.75 (approx. $9.71) per litre, it is also more expensive than its predecessor.

'Whenever there is a fuel change, we have the same challenges,' explains Millener. 'That's not normally too bad when you can plan, but this time the amount of time to plan was very limited, which made it a bit trickier. We had to work together on it, and managed to do that okay. It was just a bit of a hassle that nobody really wanted.'

WRC manufacturers initially went through some growing pains with P1 Fuels when its 100 per cent sustainable product was introduced in 2022, notably suffering damage to seals. As a result, there is anticipated to be a similar learning process with RRX AS, and the learnings from Islas Canarias won't provide all the answers.

'We don't know until we've done a few rallies and understand the situation of exactly how to look after this fuel,' says Millener, 'but that's something all the teams are going to have to learn at a similar pace.'

Despite the upheaval, Millener has no doubts about the significance of keeping renewable fuels in the WRC. Following the decision to abandon hybrid units for 2025 on cost grounds, Millener maintains that non-fossil fuels are vital for continuing a sustainable element to the WRC. He predicts they will have a part to play for years to come, ahead of changes to the technical regulations for 2027 that will permit manufacturers to use a range of powertrain options, including hybrid and full electric, given the infrastructure challenges facing some of the locations the WRC visits each year.

The FIA has been working to identify which company will hold the fuel supply contract through that regulatory transition, on a three-year basis starting in 2026.

'Fuels will continue to evolve, and e-fuels will have a part in life going forward I'm sure, alongside electric and hybrid or whatever else we have,' remarks Millener, whose company also supplies Ford Fiesta Rally3 cars for the Junior World Rally Championship. 'We've got a sustainable solution that works globally.'

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The British Special Saloons series has long been a home for outlandish creations, but few can match Peter Thurston's V8-engined Citroën 2CV

By MIKE BRESLIN

Enzo Ferrari once famously said the E-Type Jaguar was 'the most beautiful car in the world', and many would agree. So, when two gleaming examples are parked up, the sunshine glinting off their curvaceous bodywork, you might expect them to be the centre of attention. Then why was everyone looking at a Citroën 2CV parked nearby?

That was the situation outside Peter Thurston's classic car workshop in Herne Bay, Kent one morning this spring. But then this is no ordinary 2CV. It sports abnormally wide wheelarches and an aero package for a start. The most impressive thing about it, though, is hinted at by the badge on the back that reads 2CV8. That's right, this once humble French people's car now packs a 4.6-litre V8 engine.

Regular readers might have guessed by now that this is a Special Saloon, an almost anything goes category that thrived in the 1970s and '80s in the UK and, in more recent times, has made a comeback on the historic scene. Both the Historic Sports Car Club (HSCC) and Classic Sports Car Club (CSCC) run series for these cars, the latter featured in *Racecar Engineering*'s V23N9 issue.

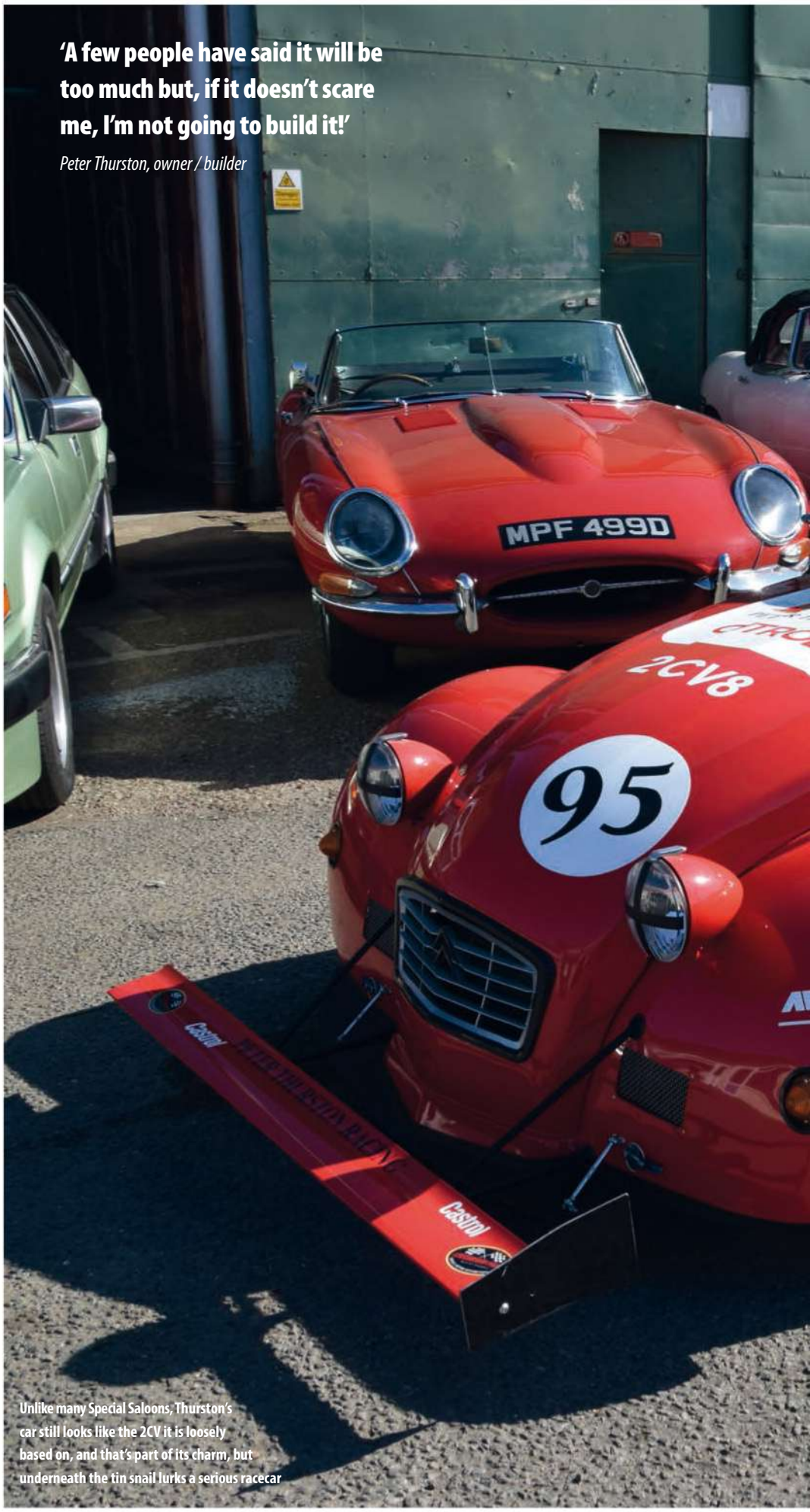
In its heyday, Special Saloons inspired some marvellously inventive machines, such as VW Beetles and Škodas with Formula 5000 engines in the back. The thing about such cars was they were rear engined and rear-wheel drive originally, as the regulations of the time stipulated that engine position and drive format remain the same as the road car any racing version was based on. That stance has been relaxed of late, so there are now Special Saloons out there that owe even less to their base car than before. Hence why Thurston built his contender out of perhaps the most unlikely racer of all, the Citroën 2CV.

Quirk of fate

Thurston, who operates Peter Thurston Racing alongside his similarly eponymous Classic and Jaguar Specialists, has competed in a wide range of machines over the years, including Formula Fords and an F2 March 832 with a turbocharged Mazda rotary engine. His real love, though, is for big power saloons, which in the past has included a 4.8-litre V8-powered Mk1 Ford Escort, a Group C2 Spice-based Honda Prelude and an Aussie V8-style Holden.

'A few people have said it will be too much but, if it doesn't scare me, I'm not going to build it!'

Peter Thurston, owner / builder



Unlike many Special Saloons, Thurston's car still looks like the 2CV it is loosely based on, and that's part of its charm, but underneath the tin snail lurks a serious racecar

L'escargo go go

At the heart of Thurston's creation is a GTS Panther kit car chassis…

…which has been enclosed in a largely stock Citroën 2CV bodyshell

All have been interesting racecars in their own right, but this latest project has rocketed out of the orbit of interesting and into the deep space of extraordinary. Which raises the most obvious question of all: why a 2CV?

'I've always liked 2CVs, because they look a bit quirky,' says Thurston. 'Then, when I was racing Formula Ford and I'd won the [Lydden Hill] championship, the local Citroën garage said, "If we give you £200 a meeting, would you race a 2CV for us? Because we want people to take them more seriously." So I did.'

That, however, was in the early 1990s, in the 2CV Racing Club series that has been catering for near-standard 'tin snails' for over 30 years now. Back then, there was even a 24-hour race for the cars held at Mondello Park in Ireland, which now takes place at Snetterton. 'I really enjoyed it,' says Thurston of the Irish around-the-clock event. 'I think all of the cars, bar one, finished. I was so impressed that when I moved to Greece for a year, I packed up a 2CV, put a windsurfer on the roof, and drove it all the way there.'

Original Panther box section spaceframe is now mostly shrouded in aluminium panelling. Incidentally, the wheelbase of a 2CV is very close to that of Caterham-type kit cars, so this was an ideal choice of chassis

Seed money

The seed of an idea to use one as the base for a Special Saloon-type car was sown at a race at Brands Hatch around 20 years ago, during a dice with a Caterham when Thurston was in his Spice Group C2-based Prelude with its Sierra Cosworth RS 500 (YB) engine.

'I had much more power so could pass [the Caterham] on the straight, but he then passed me into Paddock [Hill Bend] every lap,' Thurston remembers. 'I remember thinking, last lap, I won't go to the left, I'll go to the right, he won't dare nip up the inside then. Instead, he just went around the outside. And as he did that, I thought I need to put a bodyshell over one of those.

'I mean, there was I in a car with the underpinnings of a Le Mans racer, and this lightweight thing completely outhandled it.

'So, I did the measurements and found that the wheelbase of a 2CV is only one half-inch different to that of a Caterham.

While much of the original body frame and panels has been retained, Thurston has made the one-piece clamshell front end and extended wheelarches himself out of glass fibre

Thurston has gone to great lengths to keep the car looking as much like a standard 2CV as possible, including glueing an original roll-back sunroof cover over the car's fabricated aluminium roof

The very definition of a back seat driver, access / egress is now via the offside rear door. Surprisingly, despite the very low seating position, Thurston says this does not affect his view out of the front of the car

As I'd always liked 2CVs – though mostly just because I thought it would be fun – I decided this would make a great project.'

As things turned out, it wasn't a Caterham that offered up the base chassis for the 2CV8 but that of a similar concept, a GTS Panther kit car. This was sourced from Thurston's near neighbour, Rally Design, which was building it as a 1930s-style sportscar with modern running gear for a customer. When that project stalled, Thurston decided the chassis would make the perfect base for his V8 2CV.

A scrapped 2CV bodyshell was acquired and tried on the chassis for size. 'I didn't have to make too many modifications to the chassis, to be honest,' says Thurston. 'I worked out what I wanted to do and how, and then lifted the 2CV body over the chassis and saw it would fit and also look alright.'

The main body of the car remains steel, as much as there is in a standard 2CV, while the one-piece, lift-off front end and extravagant wheelarches are formed in glass fibre. Of the original bodyshell, which was made from thin tubing, onto which steel panels are bolted to form the skin, the structural a, b and c-post frame, along with the original doors (and wing mirrors!), have been retained. Meanwhile, the underside has been cut out and replaced with a flat aluminium floor.

Inside, the original Panther spaceframe has been clad with aluminium panels to make the bottom half of the car a sort of semi-monocoque, while the requisite rollcage, side bars and stays help stiffen up the structure.

Citroën 2CVs were built light in the first place and, even with all the added tubing, this remains a very lightweight racecar. Even with the V8 engine fitted – an aluminium block unit, so also relatively light – Thurston says the car weighed in at just 628kg. It's been painted and some additional parts have been added since then, but he is still confident it will tip the scales at under 700kg.

Citroën 2CVs were built light in the first place and, even with all the added tubing, this remains a very lightweight racecar

Thurston did toy with the idea of using a full spaceframe, mainly so he could have alternate bodies, but ultimately decided to keep it looking as much like a 2CV as possible. For this reason, the lower part of the body has not been cut down, as is commonplace in Special Saloons, where dramatically cropping the bodyshell below the lower window line is allowed as part of the 'silhouette' interpretation. That actually makes this car closer to its roots than many of the cars it competes against.

Just for fun

Again, just for fun, Thurston has taken this ethos further still by fabricating a roof that makes it look like the car retains the full-width, roll-back canvas sunroof that is such a popular feature of the 2CV.

'It looks like the original roof, but it's a sheet of aluminium, with some steel struts for rigidity, and vinyl fixed over the top. I just wanted the car to look as much like a 2CV as possible,' Thurston explains.

'Everybody said, why would you waste time putting that roof on it? And I say because a 2CV is all about that lumpy old roof. So, I bought a brand new roof kit and glued it to the aluminium roof, adding a few fake ribs for effect. I mean, if I'm going to build something ridiculous, it's got to be ridiculous, right?'

Another thing some might find a little ridiculous is the seating position, which is literally back seat driver, to the extent that you enter the car through the rear door.

TECH SPEC: Citroën 2CV8

Chassis
GTS Panther kit car spaceframe clad in aluminium panelling

Bodywork
Original Citroën 2CV frame and doors; one-piece GRP front and wheelarch extensions

Engine
Rover 4.6-litre V8; quad Weber-style IDA downdraft carbs; Piper fast road cam; homemade dry sump oiling system. Power: approx. 300bhp (full race version with around 380bhp to be fitted once chassis is sorted)

Transmission
Five-speed, H-pattern, Rover LT77 gearbox; spliced Rover / Ford propshaft; Ford Sierra axle and driveshafts; Blackline Ford LSD

Suspension
GTS Panther front wishbones and rear beam axle; anti-roll bars; Gaz adjustable dampers

Aerodynamics
Front and rear wings; aluminium diffuser and flat floor

Wheels and tyres
Compomotive outers with Revolution inners; Hoosier 10 x 20 x 13in front; 12 x 23 x 13in rear

Weight
Estimated to be below 700kg

The 4.6-litre Rover V8 engine in the car at present is thought to produce around 300bhp, but a more potent 4.8-litre unit will be fitted once the chassis is sorted. A quartet of Chinese-made Weber IDF copies currently take care of carburation

Thurston has kept the build cost of the 2CV8 extremely low (around £13,000 so far) by doing much of the work on the car himself, including making the bespoke fuel and oil systems, which are built around second hand parts

This is partly because Thurston likes to stretch out in a car – perhaps because of his single seater roots – but also because the layout of the original Panther chassis demanded it. He insists this has not compromised his view out of the front and that, by looking through the original driver's side window, he can see the top of the extended front wing, which helps with car positioning on corner entry.

Thurston is used to looking out of the side window anyway, because he loves going sideways. When he raced in Formula Ford, he was hard to beat in the wet because of his superb car control, so he never planned to build a racecar that handled like it was on rails. With the engine he's fitted, power slides in every corner are pretty much guaranteed.

'I just love having more power than grip,' he says with a grin. 'That's why I kept the Escort for so long, because of the amount of fun I was having with it.'

Where that one had a 4.8-litre version of the venerable Rover V8, one of the easiest routes to cheap power in the UK, this one is 4.6-litre, with an iron crank and a Piper fast road cam in it. 'The plan is, once I know the car works, and that it stops and corners, I've got another new block ready to go, but I'll put a steel crank in that and all the other bits.

'To build a full-blown race engine for this, I was going to spend about eight grand in parts. If I spend that money while I'm pootling around trying to get the suspension sorted, it doesn't seem worth it. So what's in it now is a donkey engine. Once I'm happy with the car, I will then put all the time into the other engine to get big brake horsepower.'

That said, the 'donkey' has enough 'horse' to be going on with, as it's good for around 300bhp, putting the power-to-weight ratio of the sub-700kg car around the 430bhp/tonne mark. The full race version will bump the figures to 380bhp and around 540bhp/tonne, with oodles of torque to play with.

'The Escort would spin the wheels, in any gear, at 1500rpm,' Thurston recalls. 'You had much more torque than you had grip, and I think this is going to be pretty much the same, which is what I like. A few people have said it will be too much but, if it doesn't scare me, I'm not going to build it!'

Budget approach

A quartet of downdraught Weber IDFs are Thurston's carburettors of choice but, much as with the car itself, these are not quite what they seem, and this has been the cause of some concern. 'My biggest single worry is how well the engine will run on those carbs, because they're not really Webers, they're Chinese copies,' explains Thurston. 'When I've run the engine, it has not been quite right on two cylinders. I took all the plugs out and compression tested it, and the compressions were all spot on, so it's probably that one carb. I will have to take that apart and see what's wrong with it.'

The engine has a dry sump, which Thurston made himself by modifying a regular Rover unit. 'I found a dry sump pump on eBay, exactly the same as I used to run on my Escort, but it came with the whole kit from a Formula Ford 2000. So, I cut the Rover sump down, made up all the baffling inside, and the channels in the bottom, and then melted the braze to get all the unions, pick-ups and strainers out of the FF2000 sump and brazed them back into the sump I had made.'

The front pulley to drive the oil pump received similar DIY attention, with Thurston fabricating parts from scratch on the workshop lathe. How the whole oil system will function in race conditions is another slight worry, but not one that fazes Thurston.

The full race version [of the Rover V8] will bump the figures to 380bhp and around 540bhp/tonne, with oodles of torque to play with

'I haven't run it for any length of time with the dry sump pump on it and, because it's twin scavenge it's quite complicated, so I'm just hoping I've got all my guesstimates right.'

If it doesn't work at first, you can be sure Thurston will find a way to make it work, just as he found a way to fit the V8 into a chassis that was never designed for such a power unit in the first place. To achieve that, he has had to be creative with some elements, the exhausts, for example, exiting through the now redundant front doors.

When the racier engine is fitted, the car will need a suitably serious transmission, but for now the gearbox in the 2CV8 is a five-speed, H-pattern, Rover LT77, the same unit Thurston used in his old Escort.

'I must have had 13 years' racing with that gearbox in the Escort and, honestly, I never even changed the oil in it, I just checked the oil level,' he says. 'Because everybody told me those 'boxes are no good, that they don't last, I kept thinking why bother changing the oil if this is going to be the meeting at which it might break. Only it never did.'

There's also a spliced – Rover at the front and Ford at the rear – propshaft, which connects to a largely Ford Sierra rear end, including the driveshafts. The differential is a Blackline Ford LSD, while for now the clutch is just a regular roadgoing item, though this is another part Thurston says will be upgraded when the more powerful engine is installed.

Down to *oeuf*

One thing this outrageous 2CV will not have to do is drive over a ploughed field with a basket of eggs on the back seat without preparing an omelette in the process – a design brief for the original – but a certain softness is still high on the list of things to be addressed with the suspension. At time of writing, the car was running on 1.9in (48.26mm) diameter springs, which was fine when the chassis was the base for a kit car with a smaller engine and no upper body, but Thurston is now looking at uprating

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'I'm following my natural instincts, I suppose, but I'm certainly not sitting down doing loads of [aerodynamic] drawings'

Peter Thurston

these to 2.75in (69.85mm) as he's been having some small issues with binding.

The rest of the suspension is also pretty much the same as it was in the Panther, with Rally Design wishbones at the front and a beam axle at the rear. As you would expect, it's all rose jointed, while there are also Gaz adjustable dampers. Still to come are anti-roll bars, which should reduce this particular 2CV's propensity for its most famous handling trait, a severe list while cornering.

The brakes are Wilwood and the solid discs that were on the Panther donor chassis have been retained, for now, and a brake bias system installed. Tyres are Hoosier historic F2 / Group 6-spec 12 x 23 x 13in on the rear, and historic F1 / F2-spec 10 x 20 x 13in on the front. Incidentally, the rather gallic rear wheel spats have been designed so that when the car is jacked up and the suspension is at full droop, a wheel can be changed without removing the wing, or fender.

Talking of wings, the car boasts two very different types that you certainly won't find on a regular 2CV, and these are also in line for some development once the car hits the track in anger. Thurston admits his aerodynamic approach is a bit suck it and see, but then he does have experience with aero cars, including his ground-effect March 832. 'I'm following my natural instincts, I suppose, but I'm certainly not sitting down doing loads of drawings.'

The Panther's suspension has been retained, with wishbones at the front and a beam axle at the rear, while the car uses Gaz adjustable dampers and Wilwood calipers on solid disc brakes from the donor chassis

At time of writing, the 2CV8's aero package included an interesting separate wing, rather than a splitter, at the front, reminiscent of those used on 1970s Can-Am cars, and will be adjustable once it is finished. Meanwhile, Thurston has three different types of rear wing to play with during development, including a boot lid fitted with a 1980's Porsche 911 Turbo-style 'whale tail'. It's likely he will use the single-element wing that's on the car in these photos, though, in conjunction with the flat floor and a self-made, plastic-coated aluminium diffuser.

Authentic cool

While Thurston may seem a little blasé about the aerodynamics, he admits to being a bit more concerned about the cooling package, thinking he might have to make a few ventilation holes in the front of the car, though hopefully without damaging the original chrome grille he's sourced, for another dose of 2CV authenticity.

One thing that will never be authentic about this 2CV, however, is its performance, as even the output of the so-called donkey engine far outstrips the 33bhp of the puny 602cc unit Citroën equipped these cars with. While improving on this is obviously achievable, being competitive in Special Saloons is another matter entirely. Thurston remains optimistic, as well as philosophical: 'I'm hoping it will be reasonably quick, but one of the ideas behind this was to see how quick a racecar I could build without having to spend loads of money.'

So far, Thurston estimates he has invested around £13,000 (approx. $17,150) into the project, which is less than the majority of racers spend on an engine.

The 2CV8 is only just going out for its first track tests, and there is likely to be an extended development period. One thing Thurston will not have to worry about, though, is finding a place to race it, as the clubs with series catering for this sort of car have already been in touch.

'They're all messaging and 'phoning me asking if I'll come out to play,' Thurston says. 'I've told them it's a new build, but they say because I've built it how it could have been done in the '70s, using all the old parts, I can come and run with them.'

When it does compete, it will be up against some very exotic, and well developed, racecars, but you can be sure which one the fans will be cheering on from the spectator banks. And that's the point, this project is all about fun. One of Thurston's more random ideas is to put a large aluminium key on the back of the car, so it looks like it's clockwork, something guaranteed to 'wind up' the scrutineers. 'The aim all along was to build a racecar from a 2CV, but the most critical factor was that I had to smile or giggle as I was building it. If any part of it didn't make me grin when I looked at it, I didn't do it.'

A flat floor feeds into the rear diffuser, homemade from plastic-coated aluminium. Thurston has a choice of three rear wings, but the car will likely go through the early development phase with this huge, single-element example

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Patriot games

The sudden need for an engine sparked the purchase of a car by Briggs Cunningham. That car went on to become known as the American Ferrari

By KARL LUDVIGSEN

In retrospect, it's no easy task to communicate what the Cunningham sportscars meant to car enthusiasts in America in the mid-20th century. America's post-war automobiles were worthy enough, but sporting? Not at all. Not since the Auburn Speedsters and Cord 810s of the mid-1930s had American auto makers produced cars that appealed to the person for whom driving was more than a way of trundling from point a to point b.

And so it was in 1951, the 48 states were galvanised by the news that the B S Cunningham Company of West Palm Beach, Florida would not only produce a new American sportscar, but would also race a team of three cars at the 24 Hours of Le Mans. This was big news, in America and abroad.

Briggs Cunningham made many friends at Le Mans in 1950 with a sortie by two Cadillacs that placed 10th and 11th overall. That he would now build his own cars and race them in the world's best-known sportscar contest was a sensation. The white and blue Cunningham cars were destined to compete officially from 1951 through 1955, scoring 15 race victories, all of them in America. To qualify to race at Le Mans, Cunningham also had to produce a handful of road cars, which now rank as choice collectors' items.

Who was this Cunningham fellow? Above all, he was fortunate in having the means to pay his own way to Le Mans; money problems rarely troubled him. Born in Cincinnati in 1907 to seriously wealthy parents, cars always appealed to the young Cunningham. In the early 1930s, he competed in some of the events organised by the Automobile Racing Club of America. A friend remembered that 'Briggs and I had many discussions about racing together in Europe, or importing the European style of road racing to this country in the 1932-'33 period.'

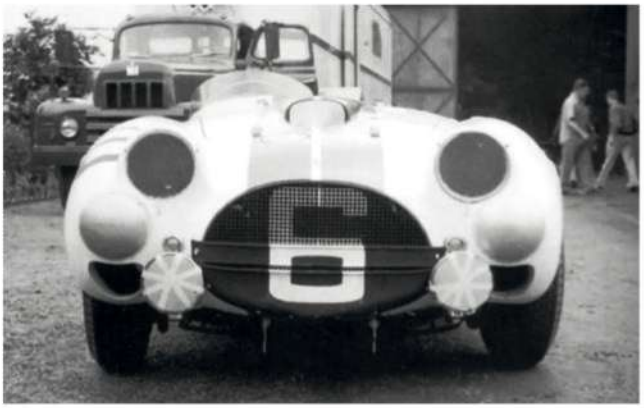
The Three Musketeers of the Cunningham team: Phil Walters *(left)* and John Fitch *(right)* flank team owner, Briggs Cunningham. They represented the US well

[Cunningham] was fortunate in having the means to pay his own way to Le Mans; money problems rarely troubled him

Also promoting this idea were the Collier brothers, Miles and Sam, both of whom raced in Europe in the 1930s. A first effort to contest Le Mans in 1951 with a Cunningham C-2 showed the car had speed, but lacked the necessary reliability. In parallel with its creation of a series production car, the C-3, the Florida-based Cunningham outfit created an all-new racecar for 1952. Designated C-4R, this was the most durable and successful competition Cunningham of all, and the model most widely known around the world. Slimmer by six inches, shorter by 16in and lighter by 990lb than the C-2, the C-4R was intended to be faster and better than its predecessors. In both respects it succeeded.

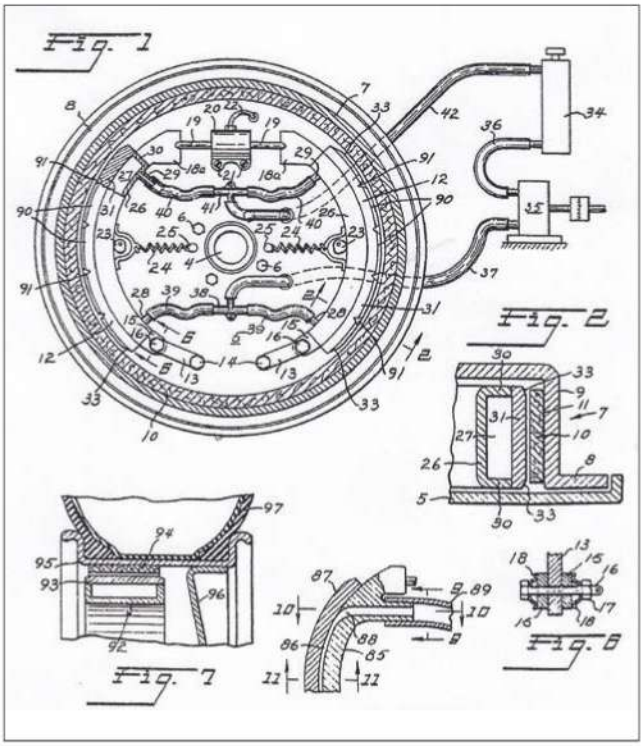
The C-4R, along with a closed C-4RK, came in seventh and tenth in 1953 and third and fifth in 1954. In domestic competition, they won in 1952 at Allentown, Thompson, Elkhart Lake and Albany, Georgia. Phil Walters and John Fitch co-drove to victory at the 12 Hours of Sebring in 1953 in the first-ever race for the all new World Sportscar Championship.

Racing in Argentina in 1954, this is one of the 26 Battista 'Pinin' Farina-bodied Ferrari 375 MM sports racers that were produced by the constructor for the 1954 racing season

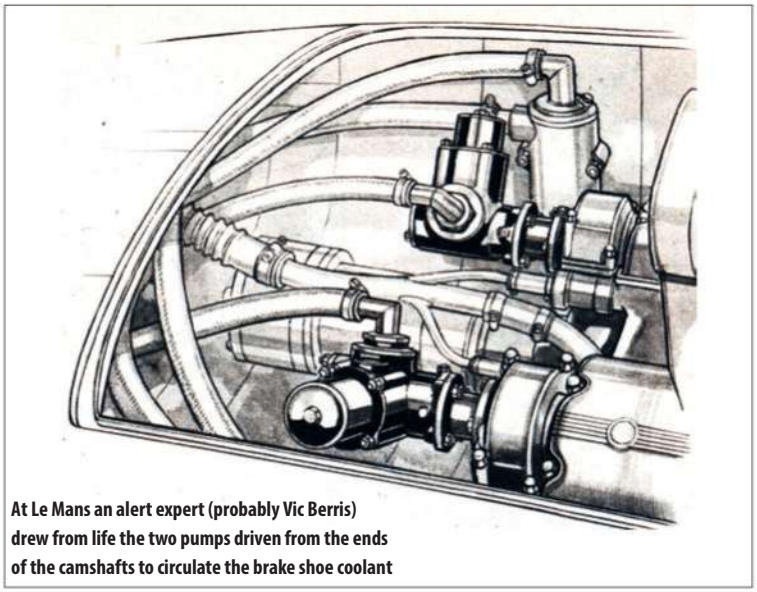


The Cunningham team took it upon themselves to completely re-body the Ferrari, introducing two additional air entries for its unusual braking system

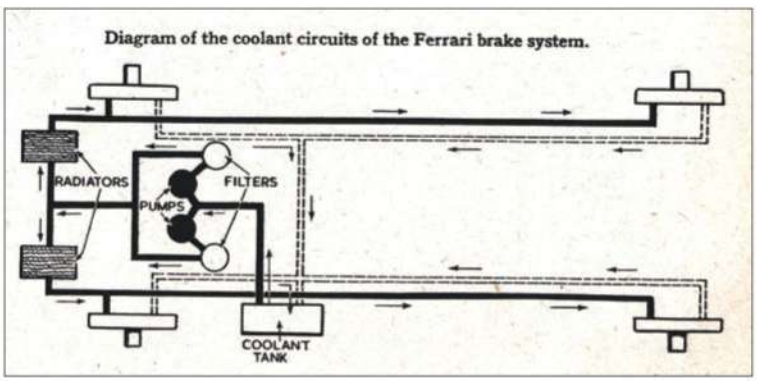
With its Cunningham designed bodywork, Phil Walters awaits his turn in the 1954 Le Mans pre-race inspection in the Cunningham Ferrari. Having first raced at Le Mans in 1950, he was no novice



The Roy Selden Sanford *et al* patent of 1954 shows how coolant is introduced at one end of the copper brake shoe and exits out the other. Note the lining is attached to the inside of the drum



At Le Mans an alert expert (probably Vic Berris) drew from life the two pumps driven from the ends of the camshafts to circulate the brake shoe coolant



The Sanford-designed brake cooling system included filters and a coolant tank to supplement its operation

A glimpse under the hood of the Cunningham Ferrari reveals devices fitted by Alfred Momo to the Weber carburettors to arrest a tendency to lose fuel in hard cornering

In addition to its engine monitoring gauges, the Cunningham Ferrari had additional readouts to assess the status of the Sanford brake cooling system

The Cunningham team prepare to leave base for Le Mans in 1954, the convoy comprising two Chryslers, a Cadillac, a truck and semi-trailer and a Bentley Continental, in addition to the three racecars

Shipping the cars to and from French ports was simplified by lifting the cars and trailers together. Here the Cunningham Ferrari takes its turn

Staying true to Chrysler V8 engines of 310bhp, a new car was fielded for 1953, in addition to the C-4R. With huge drum brakes and solid axes at front and rear, the C-5R's sleek lines had been blessed by British expert Reid Railton. The outlook was promising, but the C-5R couldn't hold the new disc-braked C-Type Jaguars at bay. As Walters said at the time, 'we could out-speed and out-drive the Jags, but on their brakes alone they easily cruised faster than we could. We ran the first two hours at our target speed, which was 104[mph], then raised our sights to catch the Jaguars. We couldn't do it.'

Walters and Fitch finished right on their target speed (+0.026mph), but seven laps behind the winning Jaguar.

Ferrari power

No new Cunninghams were built for Le Mans in 1954. Talks with Mercury Marine's Carl Kiekhaefer about a new, two-stroke, inverted V12 engine were under way, so veteran engineer, Briggs Weaver, designed the all-new C-6R to take it. As a stopgap, it was decided to use a 4.5-litre Ferrari V12 in its place. However, realising the Weaver V12 would not be ready in time, Cunningham bought one of the 26 Ferrari 375 MMs that were built in 1953. Displacing 4523cc and producing 340-350bhp at 7000rpm, car 0372AM, was an open racing spider bodied by Battista 'Pinin' Farina.

The Ferrari arrived in December 1953 and Cunningham's top driver pair of Fitch and Walters competed in it at Sebring on 7 March 1954. They worked up the field to second place but, on lap 105, the red Ferrari stopped out on the circuit. A broken connecting rod bearing was thought to be the culprit. Whatever it was, Alfred Momo and his engineers were on the case, the Cunningham team appearing a week later with a healthy Ferrari for an SCCA race at Savannah, Georgia. Bill Spear drove it there in a 30-lap race in which he ran a very close second to Jim Kimberly in an identical car.

The transformation of Ferrari 0372AM (its identity was never lost) then took place in the hiatus before Le Mans. Stripping away Farina's efforts to the bare chassis, the West Palm Beach crew produced a new, svelte, open racing body. It faced the world with an almost circular air entry and low-set headlamps on rounded wings. Further air entries for the rear brakes were in subtle screened entries where the rear wings met the main body, while twin fuel fillers on the rear deck ensured air went out when petrol went in. Though specifics are not available, this car was certainly lighter than the C-4R.

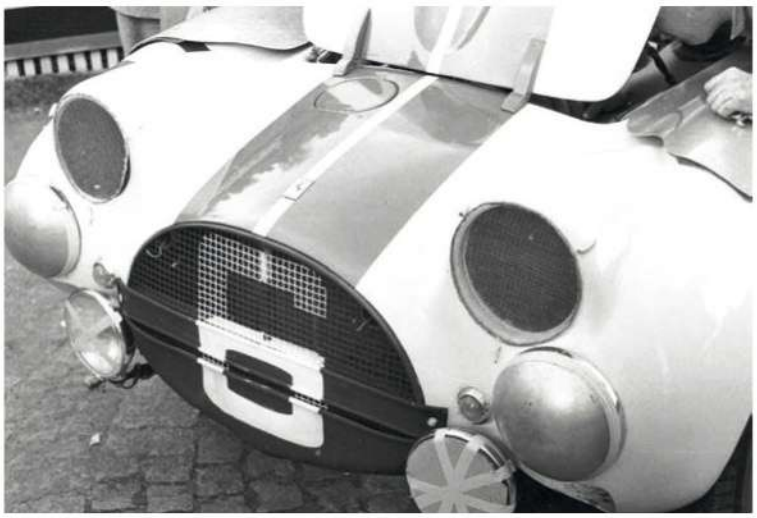
Braking, always a *béte noire* of the heavy Cunninghams, had been addressed in different ways

Brake pressure

Braking, always a *béte noire* of the heavy Cunninghams, had been addressed in different ways. Super-fine lateral finning was used on the drums of the C-4R brakes, while drivers had deceleration gauges on their dashboards so they could modulate the braking they were using. The C-5R, meanwhile, had huge, 17in brakes with centrally balanced shoes, mounted inboard to be in the airstream for cooling.

For the Ferrari, however, the Cunningham engineers tried something novel: liquid-cooled brakes. Roy Selden Sanford would design the system. Sanford was an engineer who had been filing patents since May 1921, and had come up through Bendix and then Bendix Westinghouse before starting his own

The three cars prepared for Le Mans in 1954 were two C-4Rs, one with a headrest, flanking the Cunningham-bodied Ferrari, the only right-hand-drive model built



Surrounding its almost circular central grille were fog lights, driving lights and the two meshed air scoops that led to twin radiators that were crucial parts of the car's liquid-cooled braking system

Here passing a Frazer-Nash coupé, the Cunningham Ferrari was sixth in early running, but a rocker arm breakage that reduced its cylinder count to 11 slowed its pace

The car's fastest lap of 4m26.0s was the quickest ever turned by a Cunningham entry at Le Mans, but was still 10 seconds off the best lap pace of Ferrari's latest 4.9-litre V12 racecar

company, Autotyre Co Inc, in 1941. On 3 May 1954 he, together with four others, lodged a patent on a method of keeping brake temperatures down.

'The invention,' explained Sanford in his patent, 'provides a brake mechanism wherein the friction elements which engage during a brake application are a substantially non-metallic brake lining of heat-insulating material on the interior surface of the drum and a friction element or wear surface of copper-based material on the brake shoe. One surface of the friction element closing the brake-shoe cavity engages the lining on the drum. Substantially, the entire opposite surface is in direct heat exchange relationship with the circulating cooling liquid in the cavity of the brake shoe.

'The arrangement is such that heat developed at the friction interface is transmitted directly through the friction element to the cooling fluid, so no overheating of the non-metallic lining occurs. The lining insulates the metal of the drum from the heat developed during a brake application. Consequently, the maximum temperature developed in the metal drum is so low as to eliminate entirely the problem of drum expansion [which leads directly to brake fade], as well as the problem of drum distortion or checking due to overheating of the drum metal.'

On 3 May 1954 [Roy Seldon Sanford], together with four others, lodged a patent on a method of keeping brake temperatures down

A schematic from Sanford's patent shows how a glycol-based coolant is pumped through filters and radiators into one end of the brake shoe and drained at the other, sent first to the harder worked front brakes and then to the rears. Sanford stressed the need for brake shoes fabricated of pure copper that had their 'particles fused together to form a solid and continuous mass.'

With no small diligence, this system was built and tested for Sanford by Raybestos-Manhattan. Its presence on the Cunningham Ferrari accounted for its peculiar presentation of two round radiators occupying modest dips between the front wings and the nose. Accompanying the usual cockpit instruments were gauges that would alert the driver to any major change in the system's function.

The Cunningham team enjoyed advance publicity at home when *TIME Magazine* featured its celebrated owner on the cover of the 26 April issue, which chronicled the team's pursuit of Le Mans victory. The article emphasised Cunningham's ethos of sportsmanship, bolstering the point with quotes from drivers like Stirling Moss, who said he 'really built and drove his cars because of his love for the sport… Briggs is a man I admire very much – a true sportsman.'

Next best

In pre-race practice at Le Mans, the factory Ferraris and Jaguars were the fastest, but observers credited a supercharged Aston Martin and the 'American Ferrari' with the next best speeds. This held true in the opening laps of the race, the three works Ferrari 375 Pluses seizing the outright leads. However, during the race's fourth hour, the Cunningham Ferrari suddenly went off key. The Momo crew tried all the usual tests, only to find that one of the valvetrain's rocker arms had broken. With no substitute available, they re-jigged the V12 to run on 11 cylinders.

The car's pristine appearance suggests that Rodolfo Mailander took this photo during night practice before the race. It was timed at 153.43mph on the Mulsanne Straight

In one of the hangars at Lockbourne Air Force Base in August 1954, the front end of the Cunningham Ferrari is lifted for attention. Phil Walters finished the race in second place

At Lockbourne, Alfred Momo is the centre of attention as he tends to the V12 engine. Empty radiator housings signal the removal of the car's brake system cooler

In 1994, Ed M Davies took over ownership of Ferrari 0372AM, by that point returned to its Pinin Farina guise. He has since displayed and raced the car, using the number 5 that was lucky for Jim Kimberly

Fitch and Walters resumed the race in 35th place and had advanced to 20th when, around 5am, a grinding noise signaled a rear axle bearing failure, and the end of their challenge. The American Ferrari was ranked 27th, though solace came from the finishes of the C-4Rs in third and fifth positions, team Cunningham's best result to date.

The Ferrari was stood down for the Reims 12-hour race in July, only the C-4Rs racing.

While in Europe, Cunningham and his allies paid a visit to Maranello and the lair of Enzo Ferrari. 'Briggs visited the Ferrari factory with Momo,' writes Cunningham chronicler, Richard Hardman, 'where he tackled Enzo personally about the failure of his car at Le Mans. True to form, Ferrari denied any responsibility and stated that his rocker arms do not break. He claimed that the pumps Cunningham had installed to circulate the coolant to the brakes, which were driven off the ends of the camshafts, had been responsible for the failure. To emphasise his lack of sympathy, Enzo accepted the $9.95 for the replacement rocker arm! Briggs left Ferrari in a far from satisfied mood.'

In this era of the US Air Force's support of motor racing, next stop for chassis 0372AM was Lockbourne, Ohio and its airport race track. Walters finished second there in August in the V12-powered car behind the similar Kimberly Ferrari that would walk away with the SCCA class championship that season. Sanford's innovative brake cooling system had been removed at this point, though the distinctive scoops for its radiators remained.

The only time Briggs Cunningham himself raced the car was at Watkins Glen, New York in September, finishing sixth.

Changing hands

A driver who had made his bones with the Cunningham team was Sherwood Johnston, who showed initiative with a stripped Jaguar XK120 that often harried its senior rivals. After the Watkins Glen race, Cunningham sold the Ferrari to Johnston, who scored two second places with it at Akron, Ohio in October and behind Kimberly in an SCCA National race at March Air Force Base, California in November.

In coming seasons, Johnston would prove to be a compatible partner for Cunningham. Driving the Ferrari, Johnston started 1955 with a victory at Eagle Mountain in January, two in races at Fort Pierce in February and another in May at Cumberland, Ohio.

True to form, Ferrari denied any responsibility and stated that his rocker arms do not break

His campaigning the car won Johnston the 1955 SCCA National Championship. Now with much to do for the Cunningham outfit, Johnston assigned it to Dabney Collins, for whom the powerful Ferrari was his first racecar. In five 1955 outings, his best finish was fourth at Torrey Pines in California.

Colorado enthusiast, Temple Buell, entered Collins and the unusual Ferrari in a few events in 1956, when a Ferrari 750 Monza became a rival for the attentions of both men.

Thereafter, the unique Cunningham-bodied 375 MM Ferrari left the contemporary racing scene. 'Buell later sold the car to Gary Laughlin of Texas,' Richard Hardman relates. 'From him, the 375 MM went to Bruce Lavachek and Michael Lynch. Michael Sheehan subsequently brokered the sale of the 375 MM to Zambelli, who had the car restored in Italy.' Restored, that is, to its original Pinin Farina-bodied configuration.

'The car was advertised for sale in 1994 for $890,000,' Hardman continues, 'and was subsequently bought by Ed M Davies from Hobe Sound, Florida. Under his ownership the car has appeared at various events, including the 1994 Colorado Grand and the Cavallino Classics in 2001, 2003 and 2006.'

Since acquiring the car in '94, Davies has displayed and raced it with vigour. Though its unique history is not always celebrated, we all know it's there, somewhere.

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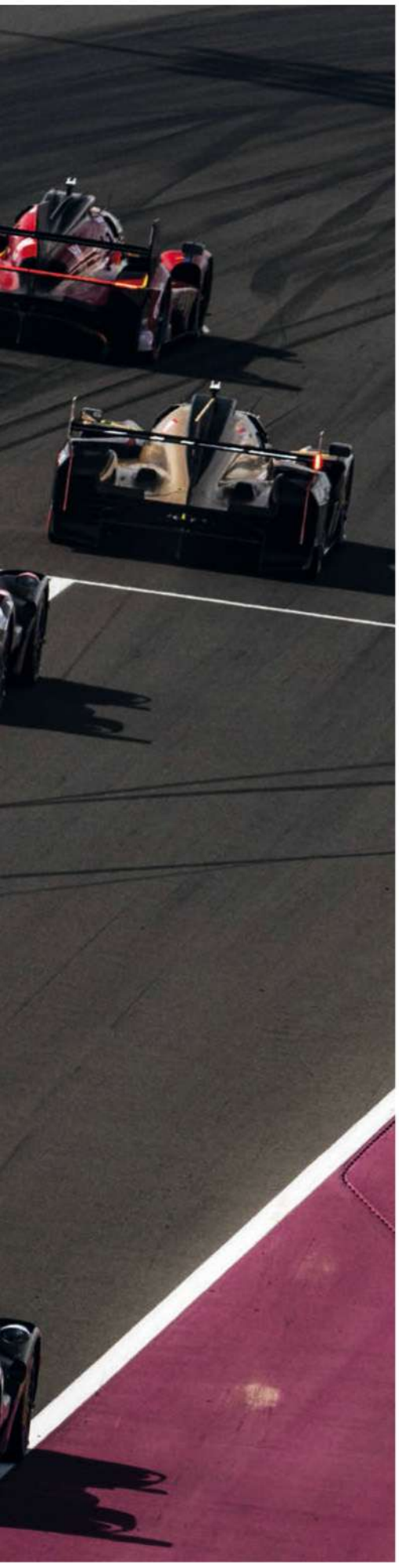
With eight manufacturers competing for overall honours in the Hypercar class, the ACO and FIA remain confident that the BoP system works, ensuring all have an equal chance of victory



Photos: DPPI

History repeating?

The form book of the first three races should probably be ripped up for the 24 Hours of Le Mans, but it still makes an interesting read

By Paul Truswell and Andrew Cotton

Ferrari has dominated the opening three races of the FIA World Endurance Championship, winning each from pole position. The question is whether or not it can translate that early form into a third straight win at the 24 Hours of Le Mans with its 499P. The Balance of Performance will be completely different for Le Mans, and the organisers are not planning to reveal what they are going to do until the cars are at Le Mans, but there are trends we can see already.

Although the WEC has lost Lamborghini for the 2025 season, it gained Aston Martin and so can still boast eight manufacturers competing in Hypercar. That alone is a fantastic testament to the current rule set, with OEM competition departments able to guarantee they can compete for overall victory (thanks in no small part to Balance of Performance) with the option of running a hybrid car. More newcomers are arriving too, in the shape of Genesis in 2026, and then Ford and McLaren in 2027.

The racing has been tight among the Hypercar manufacturers in the first three races, Ferrari hotly pursued by Alpine. The stiff competition started in Qatar in March, before heading to Imola in April and then Spa in May.

Interestingly, each of the circuits used for the first three races this year has very different characteristics. The heat and track surface at the Lusail circuit in Qatar lends itself to running harder compound tyres, and the smooth track allows cars to run at low ride heights. Imola, on the other hand, is notoriously narrow and bumpy, so track position is everything. It is hard to overtake in normal conditions, meaning teams used tyre strategy as a tool, with some implementing it better than others. Ferrari made their car work well on used tyres. At Spa, it was unseasonably warm and dry throughout the weekend, yet BMW was still able to run the soft compound tyre at the start of the race and make it work, while others anticipated a full race on the Michelin medium compound.

Advantage Ferrari

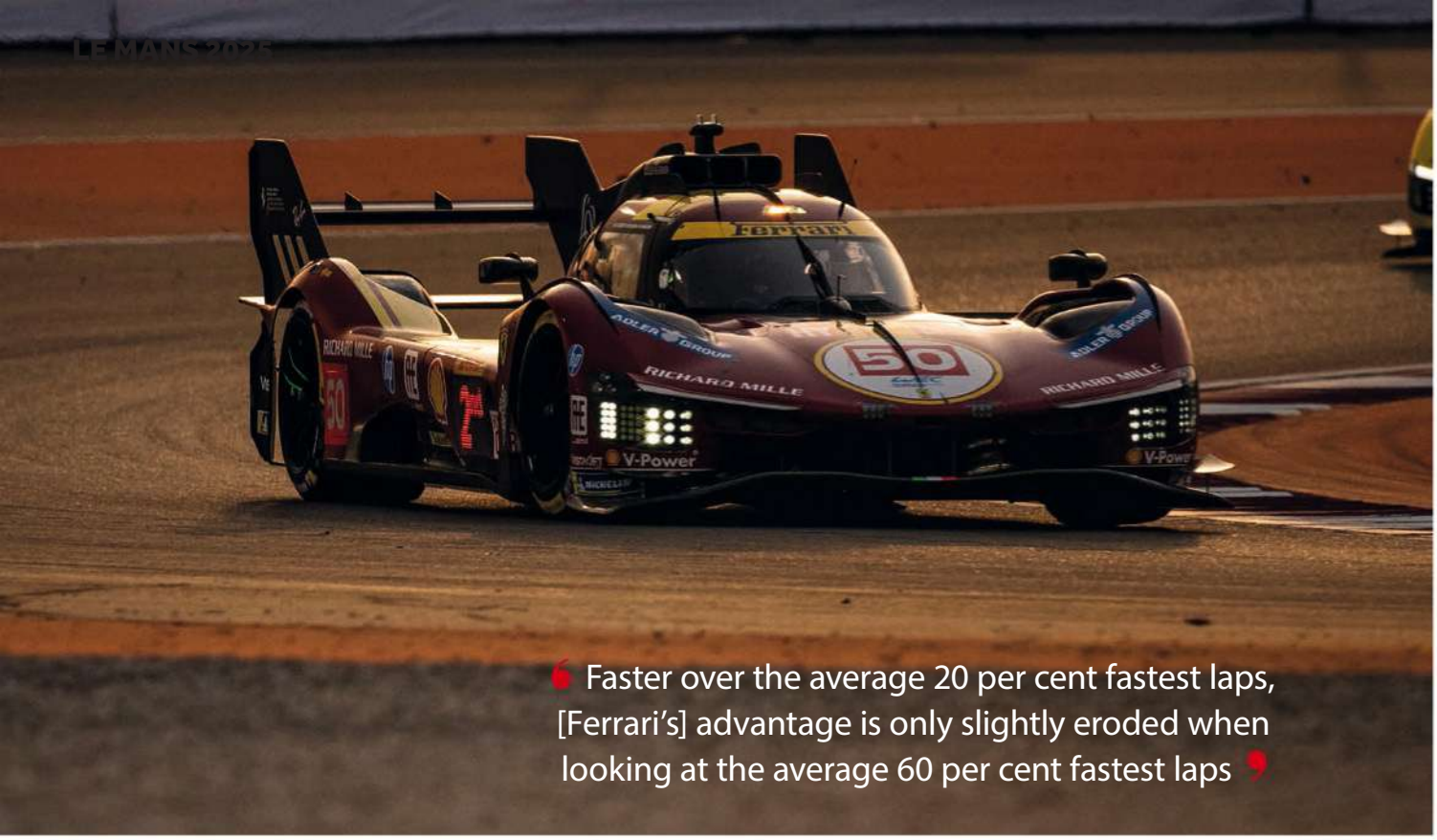
In all conditions, however, Ferrari's 499P has had the advantage, in both qualifying and race conditions. In Qatar, the AF Corse-run Ferraris were first and third on the grid, split by the BMW M Hybrid V8 of Dries Vanthoor. At Imola, Ferraris sat first and second, and one factory car had its laps deleted for exceeding track limits. Meanwhile, at Spa, it was a Ferrari 1-2-3 in qualifying.

During the races, Ferrari scored a 1-2-3 in Qatar, won at Imola, and finished first and second at Spa. The only mechanical blot on their copybook was the customer AF Corse car at Spa, which suffered a turbo failure caused by a separate issue that was not fixed during the race.

> Such has been [Ferrari's] success, it led to one rival driver commenting at Spa that the 499P 'out-performed the BoP' in qualifying, and so it seems

So, what has changed for Ferrari? The Italian manufacturer has worked hard over the winter to improve in every area. From staffing changes to set-up processes and knowledge of the car itself, there have been improvements. Such has been its success, it led to one rival driver commenting at Spa that the 499P 'out-performed the BoP' in qualifying, and so it seems. The BoP system is supposed to balance the cars but, with two races' worth of data, some have questioned the outcomes, although the FIA and ACO remain confident in the process.

From the introduction of the 499P in 2023, one of its weak points was that it was hard on tyres, unable to make them last as well as the Toyota GR010 Hybrid. The Toyota was particularly good during the second stint on the same tyre, but other teams have now caught up to that trick, and the BoP system has changed to accommodate that as well.



> Faster over the average 20 per cent fastest laps, [Ferrari's] advantage is only slightly eroded when looking at the average 60 per cent fastest laps

Ferrari has worked hard over the winter to improve tyre wear, enabling the 499P to run a more aggressive set-up and make better use of the softer compounds of tyre

The 499P was effective at Le Mans in 2023, but it was changed after that historic victory with modifications to the brake cooling and the effectiveness of the rear wing.

Since then, the team has worked to improve tyre wear on the car to better enable it to run softer (read: faster) compounds, and make them last throughout the mandatory double stint during a six-hour race. It has also gone more extreme on set-up for each track, which has translated into results this season.

Free pass

The BoP table uses only race data, and so qualifying is a free pass that Ferrari has exploited to its maximum. Track position has proven even more important in the races as the competition has closed up. Starting at the front, therefore, has given Ferrari a good leg up from the green flag. It has then shown startling form compared to the others under race conditions. Faster over the average 20 per cent fastest laps, its advantage is only slightly eroded when looking at the average 60 per cent fastest laps.

> It's not about finding the magic bullet, it is how consistent can you be, close to the limit, so you actually deliver the maximum performance

Sébastien Viger, Hypercar technical manager at BMW M Team WRT

Reigning champion, Porsche, has a new aero kit for the WEC and IMSA races. The Penske factory team saw excessive wear on its strakes in the rear diffuser and had to make a change. It took the opportunity to clean up other areas of the floor, too. Although the Porsche 963 went undefeated in the opening four IMSA Sportscar Championship races, results in Europe so far have not been forthcoming, and there is a chance the company will run out of patience before the end of the year and end its WEC programme.

BMW, on the other hand, is making good progress. Having changed the brake supplier to Brembo this season, and made improvements to overall performance, it is starting to look more of a contender. 'It is not only looking for performance,' says Sébastien Viger, Hypercar technical manager at BMW M Team WRT, 'it's how the driver is capable of having some confidence that the car will repeat lap after lap. There are three drivers and they only get a short time in the car before the race, sometimes with very different scenarios, such as high fuel, low fuel, old tyres or new tyres. So, for them having a car that is constant enough that they can expect something when they jump into the car. This was not the case before.'

Finding consistency has been key to moving the BMW up the grid, not only in terms of hardware, but also in hybrid software development. 'It's not about finding the magic bullet, it is how consistent can you be, close to the limit so you actually deliver the maximum performance,' says Viger.

Alpine is another that has taken a huge step forward in reliability and consistency. With ex-Porsche wheelman Fréderic Makowiecki on the driving team, an expert in

The Cadillac V-Series.Rs have had a mixed season, but have been among the top 10 fastest qualifiers at each round

Hypercar performance analysis per race

Alpine has been steadily moving up the grid this season, the team's impressive performance at Spa second only to that of Ferrari

> There was clear indication that the [Toyota] GR010 is slower than the others in the opening races, but it is expected by rivals to bounce back at Le Mans.

developing tyres, alongside Jules Gounon and Mick Schumacher, it has undergone changes to the team structure. After hanging up his helmet, Nicolas Lapierre has taken over as sporting director, working under Alpine's vice-president of motorsport, Bruno Famin. The team has made changes to its 3.4-litre V6 turbo engine to improve reliability, again inspiring confidence in the drivers.

For Toyota, no hardware updates were made to the GR010 Hybrid for 2025, the team instead choosing to focus on improving software. Running closer to the maximum torque curve has been a major area of development, as Toyota Gazoo Racing Europe vice-chairman, Kazuki Nakajima, explains: 'On paper and in theory it sounds easy, but, because of the dynamic of the car, it's not that easy, and I think it's something everyone is working on, including us. We see quite a good improvement here, and it's giving us a good challenge as a team and as a manufacturer.'

Bounce back

At Spa, however, Toyota driver Sébastien Buemi was furious that he was unable to overtake another Hypercar in a straight line, and that he had few opportunities to make up positions after a poor qualifying session. There was clear indication that the GR010 is slower than the others in the opening races, but it is expected by rivals to bounce back at Le Mans.

Peugeot, meanwhile, has shown good pace in qualifying, making it into the hyperpole session (for the 10 fastest qualifiers) at every race this season. The 9X8 Evo, with its rear wing, debuted at Imola in 2024, and so had reference data for there and Spa, but not Qatar. Spa was its strongest race, but contact with another racer eliminated one car, while a poor strategy call dropped the second car out of the top 10 at the finish.

Jota runs the factory Cadillac V-Series.Rs, having raced last year with privateer Porsches, so has had to adapt to a different LMDh chassis and its characteristics. The cars led the race in Qatar until a misunderstanding behind the safety car led to a crash, but the British team has made it into hyperpole at each of the races so far this year.

Aston Martin continues to learn with its Valkyrie, the only non-hybrid LMH car in the field, powered by a normally aspirated V12.

Despite intense competition, and with the rate of learning about the car still daunting, the Heart of Racing team remains ambitious and hopes to make it to the end of the 24-hour race, and to be on the lead lap.

'I see no reason why that shouldn't be our target because you want to be competitive, but we also respect the level of the competition, and the fact we are coming in our first year, whereas people will be going with the same cars into their third year,' says Aston Martin's head of endurance, Adam Carter.

Relative performance

The BoP table is modified before each race, taking into account data from the previous two events, but it is still a hazardous exercise to extract reliable data. The official table takes the best ten laps, and the average of 60 per cent of laps. In the Relative Performance tables published here, the best-performing car from each manufacturer's stable, as a percentage against the best car overall, is shown. The average lap time across the best 20 per cent of laps is taken in each case.

A look at this data from Qatar, Imola and Spa is interesting because it demonstrates – apart from Ferrari – a distinct lack of consistency across the other manufacturers. It is unclear whether this is down to changes in BoP, or the different characteristics of the circuits. In Qatar, there was not much to choose between Toyota, BMW and Cadillac, but at Imola, the Cadillacs were off the pace, while Alpine and Peugeot entered the mix through clever tyre strategy.

At Spa, traditionally a good indication of the expected performance at Le Mans, Toyota had dropped back, along with BMW, and the pace of Alpine and Peugeot was impressive.

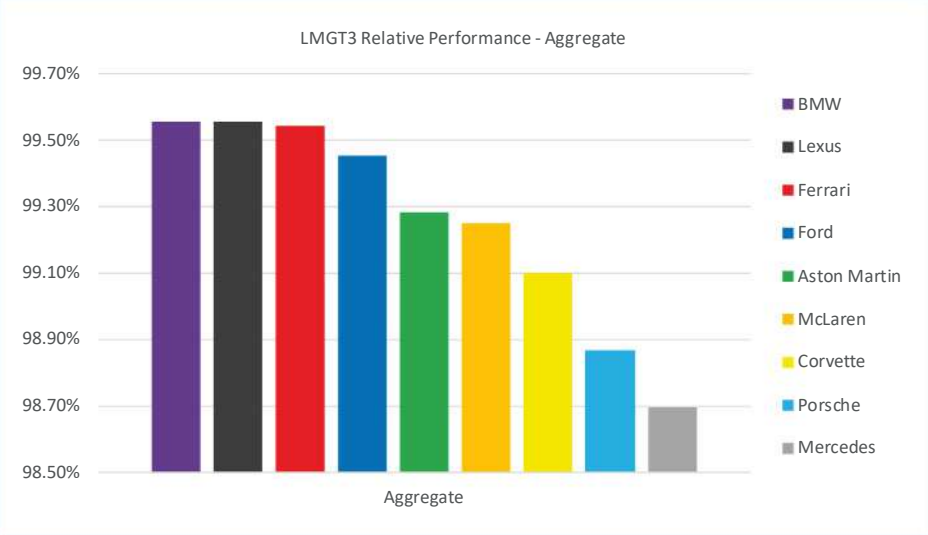
A view held by many experts is that sectors one and three at Spa present similar challenges to the circuit at Le Mans. The Bus Stop simulates the chicanes on the Mulsanne, and the sweep of Eau Rouge / Radillon and fast corners at Blanchimont require a similar set-up to the Porsche Curves or Forest Esses. As a result, consider the table showing the sum of best times through sectors one and three this year. Due to the limitation on tyre usage, it is important to look at the 'mid-range' times as well, where tyres may be going off. Hence, both the average of the best 20 per cent and the best 60 per cent are shown. Looking at the drop-off between the two also gives insight into tyre degradation, perhaps indicating Ferrari isn't necessarily so dominant.

Note that Alpine, Cadillac and Peugeot are all there. Interestingly, Toyota, BMW and Porsche are not. Unless there is something going on that is not obvious, this should concern the engineers at the brands.

There are crucial differences on pit road, with some teams able to call strategies better than others and able to execute pit stops more efficiently, while driver performance is obviously also a key factor in the overall result. One thing that did become apparent is that there is no part of the track, or grass or run-off area, that is off limits. Drivers have started to take bigger risks to overtake, as car performance is ever more tightly controlled and opportunities to progress are limited to traffic or pit strategy, particularly when the virtual or full safety car is called. Such trends should make for another exciting and unpredictable Hypercar race at Le Mans.

> Drivers have started to take bigger risks to overtake, as car performance is ever more tightly controlled and opportunities to progress are limited to traffic or pit strategy

GT3 at a glance



The LMGT3 class enters its second year in the FIA World Endurance Championship. Crucially, every car must include at least one Bronze-graded driver and one Silver or Bronze on the crew.

It has been an unpredictable season so far, with close racing normally the order of the day. After three rounds, half of the 18 full-season entries had finished on the podium. Heading to Le Mans, only two of the nine manufacturers, Aston Martin and Mercedes-AMG, hadn't seen one of their cars finish in the top three.

Reliability has been more of an issue in the GT class, with nine retirements (and one 'not classified') posted in the opening three races, compared to only four in the Hypercar category.

Looking purely at outright performance potential doesn't shed much light on the matter, although the differentials in LMGT3 are greater than in Hypercar. The Ferraris and Ford Mustang GT3s were closely matched at Spa, but the rest of the field was more than half a percentage point slower. Taking an aggregate of the season as a whole suggests BMW, Lexus and Ferrari have the quickest cars, with the Mustangs not far behind.

However, in the races, overall car performance is often dictated by the performance of the Bronze-rated 'customer' driver.

LMP2

Although no longer part of the World Endurance Championship, many of the 17 LMP2 teams at Le Mans have been busy competing in the European Le Mans Series this year. Once again, the ORECA 07 chassis is ubiquitous, the cars powered by the spec Gibson V8 engine.

The ELMS has seen rounds at Barcelona and Paul Ricard so far, but several teams had further race mileage in the Asian Le Mans Series, which visited Sepang, Dubai Autodrome and Yas Marina over the winter.

The most successful team in the ELMS so far has been IDEC Sport, which has a maximum points score in the championship, despite being beaten to overall victory at Barcelona by AF Corse, whose entry runs in the Pro-Am class.

Other strong contenders should be Inter Europol Competition – winner at Le Mans in 2023 and runner-up last year – and VDS Panis Racing.

Neither Algarve Pro Racing nor United Autosports have had particularly successful seasons so far in the ELMS, but the former won the Asian Le Mans Series title and has strong form at Le Mans, winning Pro-Am twice since it was introduced in 2021.

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Forward thinking

Michelin has finally unveiled its new range of Hypercar tyres. Racecar investigates

By Andrew Cotton

Michelin has been the sole supplier of tyres to Hypercar since the class was introduced to the FIA World Endurance Championship in 2021, and has now unveiled its range of tyres that will take the category through the next three years, starting in 2026.

The new range features a higher percentage of renewable content, in terms of steel and rubber, has better warm-up capabilities and the company is targeting an increase in mileage per set of tyres in order to reduce tyre allocations in race conditions from 2027 onwards.

The new tyre has been a long time coming, after delays induced by poor weather during the track testing phase prevented it being introduced in 2025 as planned. It replaces a range of tyres that has a storied history. Michelin's initial Hypercar concept for 2021 was very different to what eventually came to be. The plan then was that the tyre would be developed for the start of the 2021 season, and then go untouched until the end of 2024. Michelin had to do its design work

Michelin has had to cope not only with changing regulations during the Hypercar era, but also new manufacturers and new powertrain demands. Aston Martin is the newest addition to the WEC family, with a rear wheel drive Valkyrie to compete against two and four wheel drive hybrids in the same class

based solely on simulation as, at the time, there were no actual cars on track. Not only that, it had to rely on data derived from its supply to GTE cars that were of similar weight, but produced less downforce than the Hypercars, to firm up its numbers.

Given the Hypercars weigh more than 1000kg, and produce 3.5 tonnes of downforce at the highest load, producing a tyre that would remain undeveloped for four years was already a tall order for the French rubber company. Especially as the grid swelled with new cars arriving each season. In the end, various updates were introduced to accommodate regulatory and car changes.

Regulatory changes

The LMH cars originally ran the same size tyres all round, anticipating heavy load on the front axle, but with the change in regulation to restrict the front hybrid electrical energy to only come in over 150-190km/h (depending on BoP), the manufacturers switched to smaller fronts due to decreased demand, and larger rears in line with LMDh sizes.

> The 2025 tyre comprises 30 per cent renewable, or recyclable, material, and the 2026 tyre will increase that to 50 per cent

Mid-cycle, in 2023, the FIA then banned tyre warmers. An exception was made for Le Mans that year only, but they have been forbidden since, leading to some interesting strategies from the teams in race conditions. Keeping warm tyres on the car, either left or right, front or back, has been a focus of the competitors, so as not to lose time on the out laps. Michelin has addressed these issues in its new range, the first major update since the Hypercar class was introduced.

These unwieldy changes to the regulations, and car design, had to be accommodated by Michelin within its existing range, but now there has been a reset. With loads known, tyre regulations stable and track data collected, Michelin was in a much better position to embark on the development of its new range.

Targets locked

At the start of the process, Michelin set itself various targets. The first was to introduce a higher percentage of renewable, or recyclable, material and to improve the environmental impact of the racing tyre in line with its overall company values.

The 2025 tyre comprises 30 per cent renewable, or recyclable, material, and the 2026 tyre will increase that to 50 per cent.

The second target was not to increase performance through improved lap time. Instead, lap time should be stable compared to this year, but the tyre should be able to go further to increase strategy options.

The development team also looked at ways to improve tyre warm up. Without the use of tyre warmers, cars were losing too much time to risk changing all four tyres simultaneously. Now, Michelin has targeted

a first full lap loss of between three and five seconds, which is far less than teams experience with the current tyre.

Finally, there was a desire to increase the crossover point between two compounds. At São Paulo in 2024, only Toyota was able to use the medium compound tyre, which created a huge gap between it and the chasing pack that ran on hards. At Spa in 2025, only Kevin Magnussen in the BMW M Hybrid V8 was able to run the soft tyre at the start of the race, and make it work, again flattering one car against the opposition.

By increasing the crossover areas from soft to medium, or from medium to hard, more teams will be able to use their tyre of choice. That, in turn, helps the Balance of Performance engineers with their job.

Compound interest

Michelin did not feel it necessary to change the design of the carcass of the tyre for its new range, considering the initial design to be sufficient. Instead, it has worked hard on the compounds. 'We didn't bring a totally new casing,' confirms Pierre Alves, sportscar operations manager at Michelin. 'The rigidity is almost the same [as the 2025 tyre], we just introduced more sustainable material, to have the same performance for the casing. For the last three years, there has been no tyre damage in racing. That's why the casing was good [enough], and we didn't need to modify its profile or rigidity. If we did, it would increase performance, so the work on casing was not a big job. The target was sustainability, warm up and wear on compound.'

Due to the presence of BoP, there was, reasons Michelin, no requirement to improve the lap time performance, which would have led to even more headaches in the organisers' offices. Instead, Michelin focused on increasing the tyre's longevity, with a view to steadily reducing tyre allocations from four-and-a-half sets in 2025 and 2026, to three sets over a six-hour race for 2027.

Digital to reality

Having set the targets, the development of the new tyre started in 2023. One of the early tasks was to create a digital tyre model. This was achieved using both track data and simulation and is, says Michelin, an ever-evolving process that is becoming more accurate with every kilometre run on track.

'For the current and existing tyre line we made the development virtually,' says Philippe Tramond, technical director Michelin Motorsport. 'We had to change our way to design and develop. For this tyre line, the first stage has been to gather data, and then calibrate for the new technology.

'We need data from track, car and our testing machine. That allowed us to make a characterisation of the tyre. Then we are able to calibrate our virtual tyre, the Tame Tyre. Thanks to this model, we can then feed the simulator. To do that, though, you need a car model, a track, temperature data and, of course, you need a tyre model. If any one of the models is wrong, everything is wrong. Fortunately, one of our big strengths at Michelin is our tyre modelling.'

> "The rigidity is almost the same [as the 2025 tyre], we just introduced more sustainable material, to have the same performance for the casing"
>
> *Pierre Alves, sportscar operations manager at Michelin*

Michelin tested 11 new materials in this phase of development, retaining seven that were put into build. 'We tested more than 14 technical bricks, meaning change in the structure and shape of the tyre, and at the end only five were successful,' continues Tramond. 'We were really in the R&D process with low maturity, and the racing tyre is a very finely tuned product. Each time you touch something, everything can collapse.

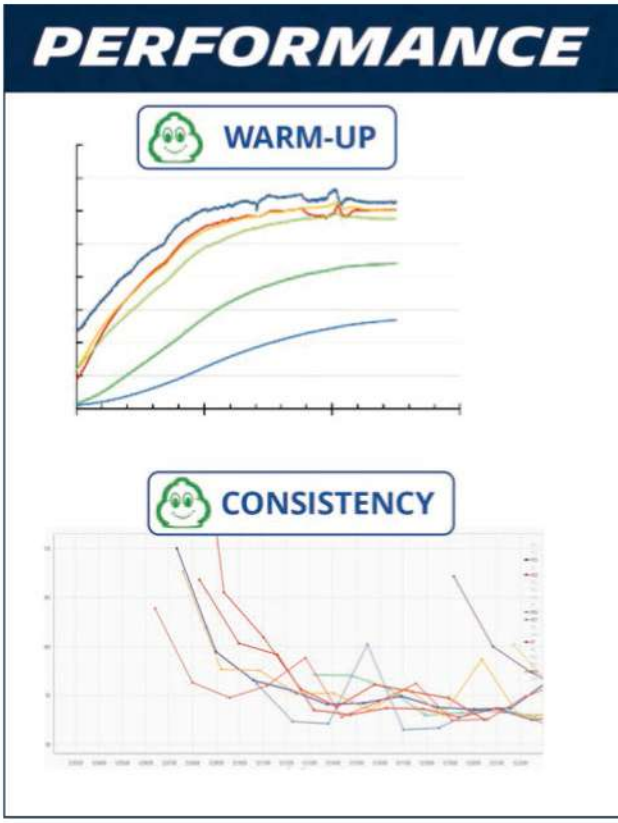
'The final stage, once we were clear about what we were using, was to get the fine tuning and validation done on many different tracks to make sure one tyre fits all.'

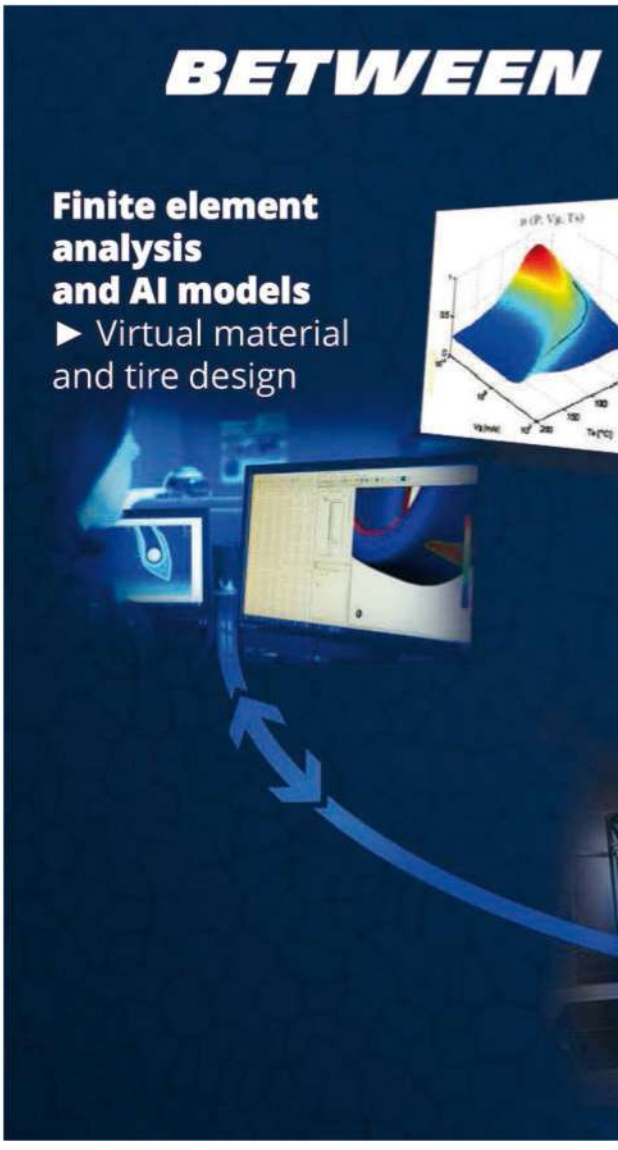
Model behaviour

Although a car may run medium compound tyres front and rear, the demands from the tyre on different axles are not the same, and so the compound is matched accordingly. Understandably, getting the balance right between the front and rear axle, and then across all cars on the grid, is extremely challenging. 'We are able to make some virtual material tuning on the model and see what is the right adjustment that we need to do to get the best balance,' confirms Tramond. 'We can simulate warm up, and we are working to simulate wear and degradation.

'Internally, we use this to support our tyre development. We supply not only a physical tyre but also a virtual tyre for [teams] to work on car settings before every race. Then after every race we do a replay to get them ready and do more virtual rather than physical development.'

All teams are provided with the digital model to help with their own simulation programmes, and in writing their strategy for each race. This model is updated after every event to ensure maximum accuracy.





TARGETS IMPROVEMENT
TYRE WEAR
RECYCLED & RENEWABLE MATERIAL
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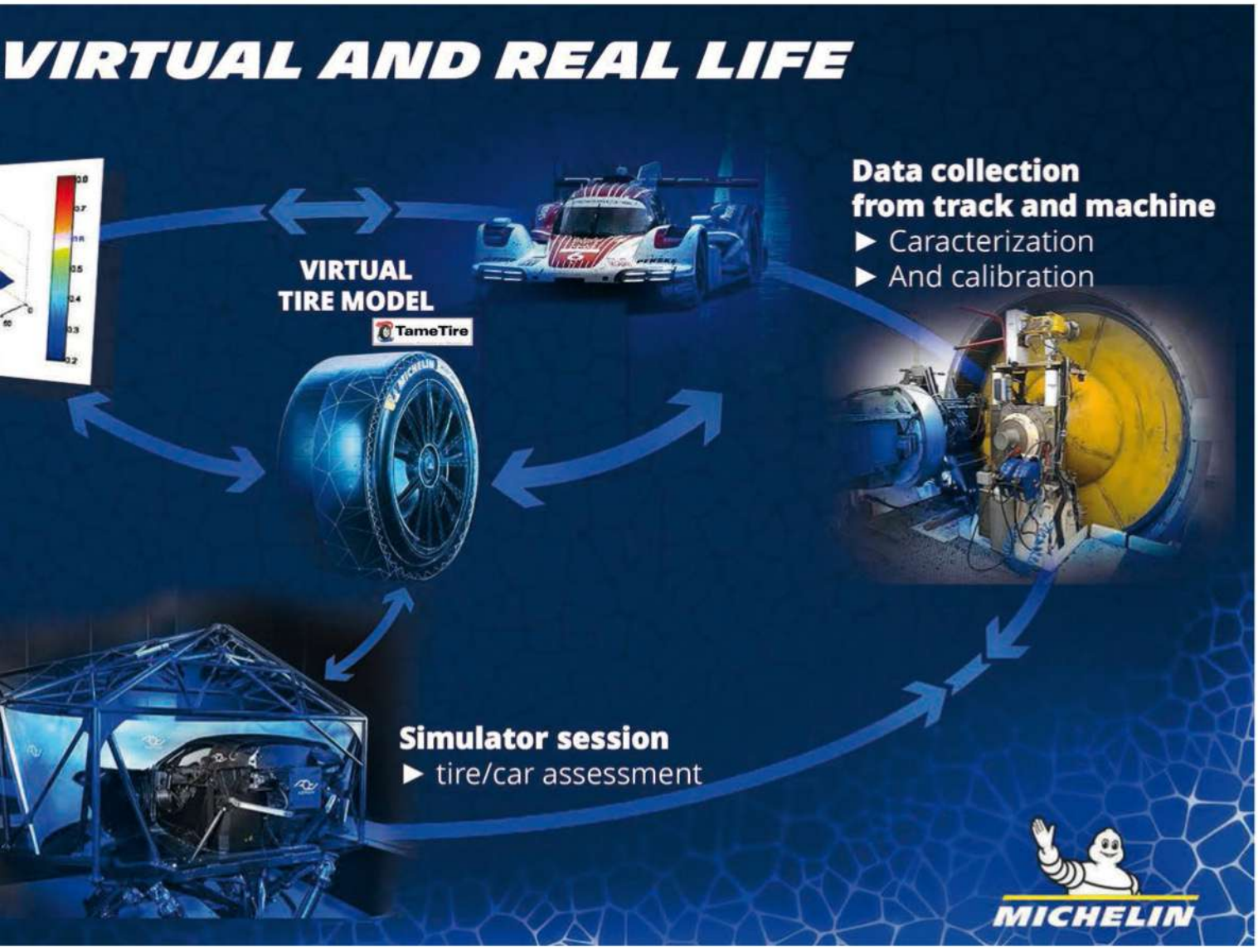
NATURAL RUBBER
BIO-OIL
RECOVERD CARBON BLACK
RECYCLED STEEL
2026 HYPERCAR/GTP RANGE


VIRTUAL AND REAL LIFE
VIRTUAL TIRE MODEL
TameTire
Data collection from track and machine
► Caracterization
► And calibration
Simulator session
► tire/car assessment
MICHELIN

Having developed the tyre digitally, the process then requires the it be physically built. Even with all its experience, that is still not an easy process for Michelin when it is looking to introduce new materials. For starters, the constituents have to be available in enough quantity to produce 30,000 tyres.

Track validation

Once built, the tyres have to be validated in real-world testing. Michelin ran through seven test loops on eight tracks with nine car manufacturers as it gathered information on the new range of tyres. Tests were conducted on both sides of the Atlantic, due to Michelin's supply of cars racing in the GTP class of the IMSA Sportscar Championship. Making life more difficult, the tests were limited to comply with strict testing regulations imposed by the various governing bodies.

The key circuits on which the tyres were tested included Portimão, Spa, Paul Ricard, Watkins Glen, Sebring and Lusail. These were chosen for the combination of track surface conditions and weather, although the Portimão tests were affected by rain in both 2023 and 2024. The 2025 test programme included two days at Lusail in Qatar to prove the hard compound tyre, then Sebring and Ricard to prove the medium, followed by Watkins Glen during the busy month of June.

There is also a new wet tyre currently being prepared, but it is not yet ready, despite the wet weather that so delayed the slick.

> Michelin ran through seven test loops on eight tracks with nine car manufacturers as it gathered information on the new range of tyres

Racecar was invited to join Michelin at one of the final validation checks, held at Paul Ricard in May this year. This date was chosen as it was close to the WEC round at Spa, and before the 24 Hours of Le Mans.

Michelin's test style is to bring a limited number of different tyre specifications to the track, and hand them out to teams along with a run plan. All cars go out with a full fuel load at the start of each run to be as close as possible to control conditions.

At the Paul Ricard test we witnessed, teams were given the first 45 minutes to set their cars up. After that, they were given a set of 2025 tyres to run as a reference. They then completed half stints for each of three sets of 2026 tyre. At the end of those three test runs, the cars were switched back to the reference 2025 tyre in order to gauge track evolution.

The high-grip Ricard track is commonly used for testing, despite its surface characteristics being so far away from the low-grip Le Mans circuit. Much of the latter circuit is also on public road, so any tyre that can triple stint at Ricard is considered good for around five stints at Le Mans.

The similarity between the two French tracks is that, without chicanes, cars can reach 320km/h on Ricard's Mistral Straight and average speeds of 204km/h around a lap. It permits a decent simulation of the speeds they will achieve at Le Mans, where 340km/h is reached. Through Signes corner, cars reach 1.1 tonnes of downforce on one tyre.

Each of the major manufacturers was present at the penultimate test at Ricard, except Aston Martin, which crashed a car in testing at Spa prior to the WEC round there. After the Watkins Glen test in the US in June, Michelin engineers will have to decide what recipe to use for the 2026 tyre, in time to deliver the first sets to the official IMSA test at Daytona in November.

Once the tyres are produced, new manufacturers entering the championship will have access to both the digital and physical specimens. Hypercar newcomer, Genesis, should begin testing in August with the 2025 tyre, before receiving the 2026 spec for the IMSA test. Ford and McLaren will also receive the 2026 tyre when they start track testing next year ahead of their 2027 debuts.

For Michelin, its hope is to improve the racing and strategy options for the teams, while maintaining tyre integrity in high-load conditions and temperature ranges.

Renewable cycle

The FIA has only just introduced a set of criteria that fuel companies need to meet in order to claim their environmental credentials, but as yet there is no corresponding guideline for tyre manufacturers. That said, Michelin has pushed for a higher degree of renewable materials in its 2026 Hypercar tyre, and has focused on end-of-use recyclability, too.

Silica has been used in tyre manufacture since 1992, but Michelin does not consider sand a renewable component. It has therefore replaced the sand with styrene, extracted from polystyrene, as part of its construction.

Michelin has also partnered with Enviro, a Swedish company that has developed a system to extract materials from used tyres, including oil and carbon black. It has a plan to build factories around Europe that will eventually be capable of treating a million tonnes of used tyres, around one third of the tyres discarded in Europe alone.

The renewable content extracted from the racing tyres will not be used again in a motorsport product, but can be used in other applications, such as the farming industry.

Putting a more global outlook on motorsport tyres, recyclability must also be considered

While we are still a long way off the possibility of recycled racing tyres, components from them are already being re-used in other applications, such as the farming industry

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Break out

The world of GT3 racing is facing a looming crisis as series set their own targets
Racecar *investigates*

By Andrew Cotton

The WEC is pushing for alternative aero and a different point in the performance window compared to other GT3 series as each seeks to impose its own stamp of identification

The world of GT3 racing is, on paper at least, relatively straightforward. The cars are based on existing high performance production models, homologated by the FIA. They are accepted for racing in national and international championships around the world and it is one of the most prolific categories in racing. All good so far.

The cars were originally planned to be cost effective, both to buy and to run, compared to, for example, GTE cars. Performance is balanced through different processes, but to the same end; to reduce the incentive to spend money developing cars, and to ensure everyone has a fair chance at winning.

However, for the 2025 season there has been a sudden change in the way the cars are prepared for competition. Series are starting to impose their own criteria based on individual needs, and that threatens to drive up the cost of competition, as well as add unnecessary complications for the teams, and the manufacturers building cars.

The manufacturers involved have called on the FIA to step in and restrict the demands of the individual series in order to protect the future of GT3. This has become an urgent issue.

Different criteria

GT3 cars have been exported worldwide and appear in different national, regional and international series. At the global level, they appear in the FIA World Endurance Championship (featuring the 24 Hours of Le Mans) and the Intercontinental GT Challenge (IGTC), which includes major 24-hour races at Spa and the Nürburgring. There is also the GT World Challenge, which has distinct series in Europe, North America, Asia and Australia. Other arenas include the IMSA Sportscar Championship in the US, the DTM in Germany, the British GT Championship and the Thailand Super Series. Each of these has different criteria: some are sprint races of an hour, others are long distance; some are for one professional driver only, others for a combination of pro-am drivers; some use a control tyre, while a handful of outliers, such as the Nürburgring-based NLS and Super GT in Japan, have open tyre competition.

To further complicate matters, each of the series that runs GT3 cars has its own Balance of Performance system, with different tools available to its engineers. To this end, and to give individual series their own identity, some series such as the WEC and GTWC Europe have decided this year to apply a separate homologation document, supplementary to that produced by the FIA.

This allows their performance balancing system to take place with data relevant to their series, and caters to their different sporting needs, such as pit stop times.

Communication with the fans, via leader lights and pit stop timing data in the door panels for example, is another change that demands different parts for each series.

Sensor split

The biggest difference between the series, however, is the use of torque sensors. Provided by MagCanica in California, these driveshaft-mounted devices measure power delivered to the wheels. Their use is mandated by the FIA in its world championships, and in the FIA GT World Cup held in Macau. They have also been adopted into the IMSA championship. However, the GT World Challenge, organised by the Stéphane Ratel Organisation (SRO), has stated it will not introduce the sensor as the costs are too high, feeling it would threaten grid sizes.

> “We need one GT3 [car] that can be raced everywhere in the world without a change”
>
> *Ferdinando Cannizzo, head of endurance racecars at Ferrari*

Even between IMSA and the WEC, both of which use the same sensor technology, the way in which it is used is different. ‘We have the same torque sensor in WEC and IMSA, but different data loggers and scrutineering systems, meaning we have different software and application specs, which increase cost for technical support,’ says Andreas Roos, head of BMW M Motorsport. ‘Plus, on top [there is] a BoP, for which we need to recalibrate from race to race, in order to have competitive GT3 customers.’

Ferrari agrees. Like BMW and Porsche, it has a large number of 296 GT3s racing in different series around the world, and these changes are adding complication. ‘We need one GT3 [car] that can be raced everywhere in the world without a change,’ says Ferrari’s head of endurance racecars, Ferdinando Cannizzo. ‘Minor changes are not a problem, but the changes are becoming radical, with different sensors allowed, or not allowed, and that forces us to change the loom, which is a drama, because it is designed to have a sensor, and then it can’t have it.

> If every racing series starts writing their own GT3 regulations, the whole thing will collapse fairly quickly. That scenario must be avoided under all circumstances

Thomas Laudenbach, vice-president of motorsport at Porsche

Teams are attracted to GT racing by its availability and big prizes on offer, but the cost of competition is rising steeply

'People tend to underestimate that in a certain championship you process different sensors, or the same sensors in a different way, which for the manufacturers means different software. That means we need to spend time to write different codes, debugging on track, and having people to install the right software or calibration. [For] a torque sensor that is the same in different championships, the way you analyse, post process [and] close the loop means you have to have different software, so double the development. It becomes crazy.'

Porsche, too, is careful to point out that the differences are not what the series needs, and that costs need to be brought back under control. 'You can put them in or leave them out, but I still have the same car,' says Porsche's vice-president of motorsport, Thomas Laudenbach, regarding the use of torque sensors. 'But on top, and as a consequence, you then have different marshalling and scrutineering systems. In a perfect world, this is not necessary at all; if the racing series would talk to each other and agree on the same systems.

'Right now, all these small differences are manageable, but I'd like to make the point that the global tech specs in GT3 racing should not drift apart any further. If every racing series starts writing their own GT3 regulations, the whole thing will collapse fairly quickly. That scenario must be avoided under all circumstances.'

Aero options

Other changes between series include the aerodynamics. Teams competing in the WEC race at Spa in May complained that their cars were qualifying in the region of 2m18s, while for an SRO test, just three days later, times were in the 2m16s. Admittedly, tyres were different, with Goodyear supplying the WEC cars and Pirelli the SRO, but the difference in lap times was more about aerodynamics; teams noting that straight-line performance was also different between the series.

This, despite all cars being homologated in the Windshear wind tunnel in the US as Sauber's facility, formerly the reference tunnel for the FIA, has been turned over to Audi's Formula 1 programme. Ideally, data should be shared between all series if the cars are tested in this controlled environment, but it is not being used that way.

'We are treating GT3 more like Hypercar, so we measure everything on the car like the top class, but we are racing this car in a different championship, mostly pro-am cars, and the promoter has their own BoP. They don't care about the nominal value we measure during the homologation process,' says Cannizzo. 'The question is why we need to spend this money for something that is not useful. Alternatively, if you give a value to the money you spend, you use the information in a proper way.'

In 2021, the WEC proposed a revised aero kit that would give the LMGT3 cars a new look, but would be benign in terms of aero performance when compared to the existing cars. That proposal was roundly rejected at the time but, incredibly, it seems it is now back on the table as a possibility.

'Porsche will not build a special GT3 car for Le Mans. It would be financial suicide. It doesn't make any sense,' says Laudenbach. 'If they push for that, we will be gone, because we don't have the money to do it, and don't want to do it, because we need to protect the business case of the GT3 class.'

BMW is similarly adamant: 'We were against the original idea to implement a special aero kit for Le Mans, together with most of the GT3 manufacturers,' says Roos. 'Our position hasn't changed. We are totally against it and, to be absolutely clear, this will not happen with us.'

Performance windows

Yet the WEC's desire to make the cars different still exists. Instead of new aero, the organisation instead changed the performance windows, increasing power and drag compared to the base model. If the reasoning behind that is

The cost of competing in the SRO-based GT series is less than in the WEC, and the technical regulations are very different as the SRO steadfastly refuses to introduce torque sensors and is focused primarily on customer racing

IMSA's communication with its audience is very different to that of other series, meaning alternative door light panels for the cars are required, while the circuits are also very different on either side of the Atlantic

just to be able to claim to have the quickest GT3 cars in the world, there are other options than changing the base car, says BMW.

'If you compare qualifying lap times at Spa between the [SRO] 24-hour race last year and WEC qualifying this year, there is a lap time delta of four or five seconds, with the same car,' notes Roos. 'It means we are running the same car with less power and more weight in WEC, as well as a slightly different aero configuration and different tyres. So, theoretically, we already have a car that could be significantly quicker. So, if the ACO and FIA want to have quicker lap times in LMGT3, it could be done simply with a different BoP.

'Secondly, if the ACO and FIA wish to have, let's say, the quickest GT3 cars in the world, they could also introduce a different tyre specification. Meaning they have two powerful tools to achieve their goals without changing the car.

'To change the globally unified tech spec of GT3 is not the way to go, because that's the basis of its success.'

> "To change the globally unified tech spec of GT3 is not the way to go, because that's the basis of its success"
>
> *Andreas Roos, head of BMW M Motorsport*

Rising costs

To put some of this discussion into financial perspective, torque sensors are priced around €10,000 (approx. $11,300) per sensor, so €20,000 per axle, calibrated and fitted. But they are lifed, and require replacement during the season, plus spares are needed and repairs inevitably required, which significantly increases the bill to a team.

Wind tunnel testing costs have also risen with teams now having to homologate their cars in the US, rather than in Switzerland. Transport costs are also increasing due to global pressures, all of which is making GT3 cars more expensive to run.

The cost to compete in GTWC Europe is estimated to be just under €2m (approx. $2.26m) per car, while the budget for a WEC team is estimated to be between €4.5 and €5.5m (approx. $5.085-$6.215m) per car, although transport costs are higher, race mileage is greater and the technology is different in the world championship.

Perhaps more relevant is the cost per kilometre for a GT3 car, which has risen from around €10/km (approx. $18.25/mile) for an older Audi R8 LMS to between €20 and €35/km (approx. $36.5-$64/mile) for a current GT3 competing in the WEC.

BMW was expecting to go two seconds faster in the 24 Hours of Spa than in the WEC race at the same Belgian track, and did just that in the prologue, thanks in part to a different aero package

OEM consensus

The manufacturers all agree that there is a need to differentiate between the various series, and understand that they will need to accommodate these changes, but they want to keep them to a minimum. There is a fear that, having now introduced a separate homologation document, that could grow to include other, more significant demands, and differences in cars, so are hoping the FIA steps in to stop the practice.

'The FIA GT Commission is the right place in my view to have this discussion,' says Roos. 'It's the job of the GT3 manufacturers to address these topics in the commission meetings. I can only speak for BMW, but for us it is not an option to have five or 10 different technical specifications for the GT3 class.'

'If we want to have an affordable, or sustainable, category, we need to get rid of what is not really useful for its success,' adds Cannizzo. 'I'm not saying that we need to live in complete freedom, but we need to be aware that some things can be done in a different way. Sustainability in the long term is something that for sure we need, because currently the situation is great. GT3 is really successful as a category, but the big question we need to raise is, is this situation sustainable in the long term? Because if not, [GT3] will disappear quickly.'

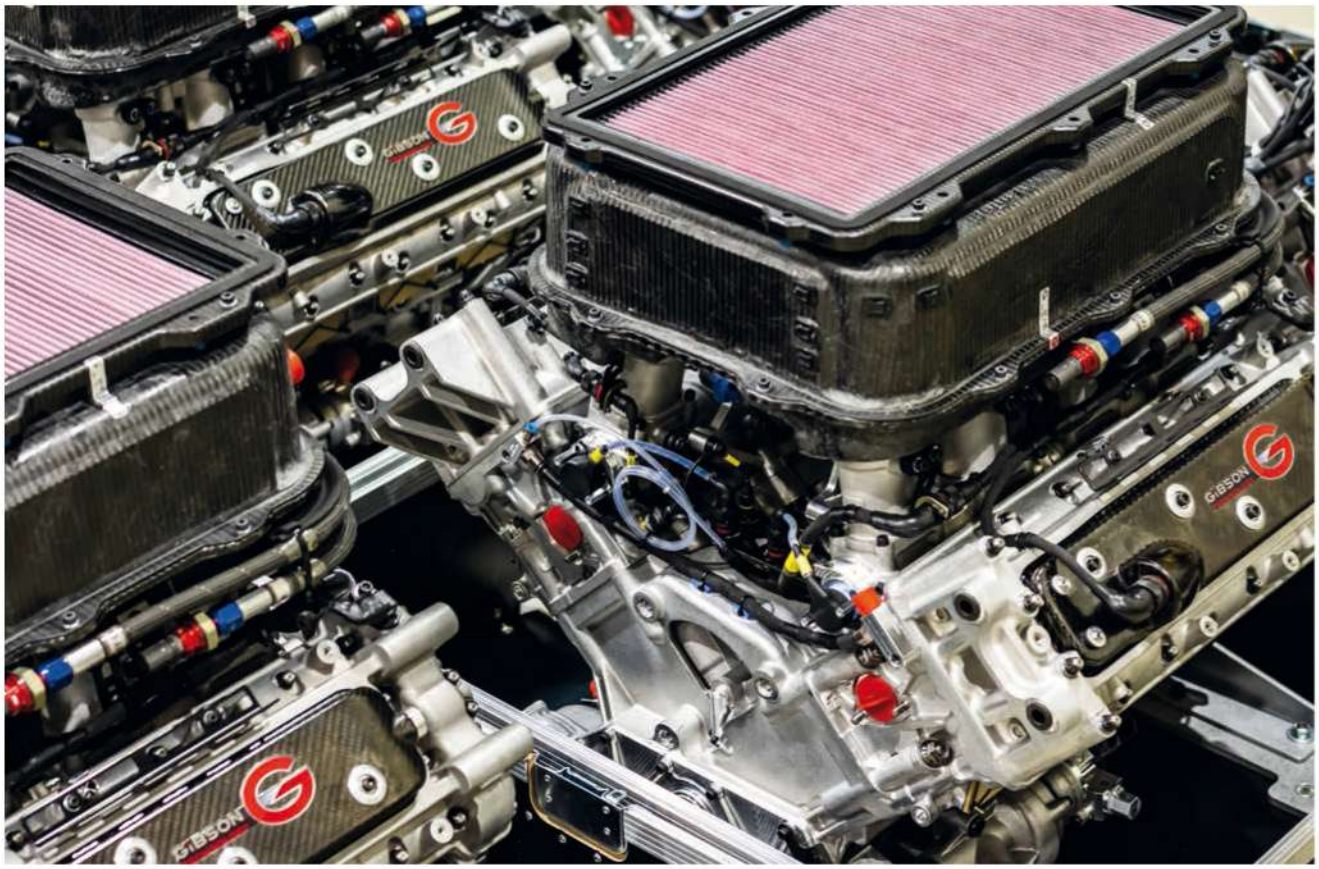
Porsche is in agreement: 'With every manufacturer I talk to, I got the impression they all seem to agree; we need to eliminate the threat,' says Laudenbach. 'They all say the same: we want one car for the whole world. I think the most important thing is that all GT3 promoters accept and respect the wording and the direction from the FIA GT Commission, which is the right place to tackle the problem.

'Sometimes you need exceptions from the rule, for example in a sprint series like DTM, which creates new problems for the class, hence you need to adapt slightly if necessary. This is something we can accept, but we need to keep up the idea of a global spec, otherwise GT3 is going to die.'

Broader minded

Gibson Technologies has long championed the naturally aspirated engine, but is now looking to adapt to the evolving motorsport landscape

By Daniel Lloyd



Gibson Technology

British engine builder, Gibson Technology, formerly Zytek, has become well known in sportscar racing for its supply of the powerful V8 engine used in LMP2 since 2017

For most of its existence, both as Zytek Engineering and under its current guise, Gibson Technology has championed the normally aspirated engine. The Derbyshire, UK-based firm has been a leading racecar engine builder since the 1980s, with its best known work taking place in single seaters and sportscars.

Since 2017, Gibson's 4.2-litre V8 (GK428) has been the licenced engine of LMP2. Anybody who has been to the 24 Hours of Le Mans in the last eight years will be familiar with its hair-raising soundtrack.

However, Gibson is aware that its propensity for big, noisy V8s is at odds with the directions being taken by many high-level series. Across motorsport, organisers are chasing lightweight, efficient, turbocharged engines. In Formula 1, V8 and V10 have become heritage terms, as the championship gallops through its second decade using the 1.6-litre, turbo-hybrid V6. Rally1 cars use a 2.0-litre, turbo, inline four, while the LMP3 sportscar formula has just switched from a rumbling V8 to a V6 turbo.

When the FIA launched a tender in March this year to identify the next LMP2 powertrain and electronics suppliers for 2028, it specified a preference for a small capacity, turbo engine. It seems the V8 is being regulated into a position of endangered species at certain levels of the motorsport pyramid. The question is how will Gibson navigate these changing tides to ensure its long-term stability?

Company background

Bill Gibson and Brian Mason founded the company in 1981. A control systems engineer at Lucas Automotive, Gibson noticed that engine management systems for the road were advancing at a faster rate than in motorsport. After leaving Lucas, he and Mason set up Electronic Racing Aids (ERA), assembling devices in a home kitchen. The small company had its breakthrough when Hart agreed to run ERA's digital management system on the engine powering its 1984 Toleman F1 car, famously driven by a young Ayrton Senna.

By the late 1980s, the pair had gone their separate ways, and Gibson had re-named the company to Zytek, which expanded into engine design and manufacture. Its first major spec supply contract was to Formula 3000 from 1996-2004. Zytek also supplied V8 engines to A1 Grand Prix and Formula Renault 3.5.

Aside from engine building, Zytek added electric motors to its portfolio in the '90s, designing its systems in-house. Projects included making an energy recovery system and e-motor for the Panoz Esperante Q9 GTR-1 Hybrid sportscar of 1998 and working with Mercedes-Benz HPP on the first kinetic energy recovery system (KERS) to win a Formula 1 race in 2009. Purchasing some of Reynard's assets meant chassis design was pursued in sportscars, taking Zytek to the LMP1 class.

Gibson Technology

Normally aspirated V8s like the GK428 have been Gibson's forté for years, but it is now having to consider other options

> "In the early days, the time between rebuilds was about 40 hours. With development over the years, we now get 80 hours between rebuilds"
>
> *John Manchester, advisory director at Gibson Technology*

The last Zytek chassis was the Z11SN (later re-branded to the Gibson 015S), which twice claimed LMP2 honours at Le Mans.

The 2014 re-brand from Zytek to Gibson occurred in the context of the Zytek Group comprising two divisions. Zytek Automotive focused on road car technologies, while Zytek Engineering covered motorsport, although there was crossover on some projects. When Fradley-based Zytek Automotive was sold to Continental, Repton-based Zytek Engineering remained under Bill Gibson's control. To avoid any confusion, Zytek Engineering was re-named Gibson Technology.

Defining project

The defining project for Gibson since then has been its LMP2 engine supply deal. Until 2017, the second-tier class at Le Mans was open to different engines, and Gibson was a key player with its 4.5-litre Nissan VK45DE V8. It was then successful in applying to build the common engine for the class, which was introduced as a cost control measure. The deal wasn't supposed to last as long as it has done but, as the FIA and ACO kept delaying the next LMP2 rule set (which is now tabled for 2028), Gibson became more entrenched in the endurance ecosystem. As the seasons flew by, so trust among the teams leasing its engines grew.

The GK428 was built to make 450kW (600bhp), although the power output now differs depending on the series as LMP2 is slowed for races where LMHs and LMDhs are present. This happened because the 2017 cars were much faster than they need to be today; back then the top class featured LMP1 hybrid rocket ships. The 4.2-litre V8 weighs 135kg and is port injected using the Cosworth MQ12 DI control system.

'We worked with Cosworth and the MQ12 on Renault Sport applications, so we had a good relationship with them,' notes Gibson technology and strategy director, Ian Lovett. 'It worked out quite nicely for us. The [engine has] a direct attack valvetrain. We use a bucket follower with a shim on top of the valve. It's a hollow steel camshaft with tubes up the middle and an anulus of oil that is fed through holes in the cam lobes to lubricate the follower. It's well proven, as a design.'

The GK428 can trace its lineage back to the unraced engine Zytek developed for GP2 in 2005, as the planned successor to its Judd F3000 unit. As an LMP2 engine, it was expanded to 4.2 litres but was also developed into a 4.5-litre option for LMP1. The latter version was kept on, with reduced power, for use in the Vanwall Vandervell LMH car, but struggled to meet the WEC's prescribed torque curve in hotter conditions. A more suitable V10 option was proposed but never realised.

To date, Gibson has built over 60 units of the GK428. That might not seem a huge number, at least not relative to ORECA, which has produced more than 130 LMP2 chassis in the same timeframe, but the ongoing popularity of the class has given Gibson a constant stream of rebuild jobs, which are conducted after 80 hours. Because teams are charged for engine use on an hourly rate, the longer an engine keeps running on track, the better it is for the supplier.

'In the early days, the time between rebuilds was about 40 hours,' says John Manchester, advisory director at Gibson. 'With development over the years, we now get 80 hours between rebuilds, which is equivalent to about 9000-10,000km. A lot of that is due to improvements in manufacturing, design techniques, materials and simulation.'

In September 2024, the GK428 surpassed five million kilometres in race conditions, and is set to reach 7.5 million by the time Gibson's contract expires after 2027. With the hourly lease price for the engine fixed over the first four years of the contract, it was perhaps not as lucrative a venture as it seems. Nonetheless, the security offered by the consistent work will have satiated Gibson for more than a decade when it comes to an end.

The last Zytek chassis was the Z11SN, which won Le Mans twice, in 2011 and 2014, utilising Zytek-Nissan power

Diversification

In October 2023, Bill Gibson stood down from day-to-day operations at his company. Mark Brittan, the founder and chairman's son-in-law, became managing director the following May. Brittan's appointment presented an opportunity for Gibson to evaluate its present and future. To him, it had become clear that putting all its eggs in the LMP2 basket might not be the safest long-term approach.

'When a business has so much wrapped up in one contract, it's not ideal,' says Brittan. 'For me, there was an element of risk we needed to address. I also felt there were massive opportunities. The reputations of Zytek and Gibson were so strong and, with the expertise we had, we felt we perhaps weren't taking enough opportunities. That led to a bit of re-structuring, moving away from being a single project organisation.'

As part of the re-structuring process, Gibson re-hired Dr Gareth Pugh as its head of engineering and projects to embed increased

> Now that we are widening our horizons, I wouldn't be surprised if we do something in that area [of turbos] in the next few years
>
> *Mark Brittan, managing director at Gibson Technology*

Gibson Technology

The manufacturing hall at Gibson's Repton, UK base caters to the large number of new engine parts the engine manufacturer needs for its ongoing LMP2 programme, but the company now wants to utilise this technology for a broader range of projects

project capability to support its diversification, while Lovett scouts new fields into which the company could expand. One area yielding results has been BOSS GP, a historic series for recent single seaters that can give former Zytek powerplants a further lease of life.

'The majority of cars racing in it are Formula 2 or GP2 cars,' says Lovett. 'Most run 4.0-litre Mecachrome [V8] engines. We have a lot of engines in ownership of customers that run the Dallara T12, the final derivative of the World Series by Renault car. The GP2 cars are a little quicker on the straights. We talked to the people competing and identified that a few cars weren't racing because the owner / drivers didn't feel they had a fair chance. So we looked at the engine spec, took some of what we've learned in LMP2 and applied it to an 'evo' version of the engine, using a few of our tricks to give them a spec that makes it competitive with the GP2s. We've built five of those engines since November [2024].'

Such scenarios could generate more new work for Gibson in the coming years. The company expects to remain busy with the current generation of LMP2s, which are on the cusp of becoming prevalent in historics and track days, once the new cars arrive in 2028. It is low-hanging fruit for Gibson; a low-risk option the company knows it can tackle with its current resources. There is certainly an affinity for loud V8 and V10 engines in historics, and the increasing use of biofuels is facilitating their continued use.

Future of LMP2

Gibson sees historic racing as one way of diversifying, but that does not mean it will morph into a heritage brand, only servicing technology that has become obsolete to major series. Gibson applied for the 2028-2032 LMP2 powertrain contract, for which the organisers stated a preference for a small capacity, turbo V6. If successful, it wouldn't be the first time Gibson has built a turbo engine; it developed the 3.4-litre, twin-turbo V6 that Renault Sport used for its R.S. 01 GT car. However, it would still be a big change for a company renowned for its naturally aspirated V8s.

So why has Gibson been such a proponent for normally aspirated engines when many of its competitors have focused on turbos for longer?

'The installation that's needed for a normally aspirated engine is minimal compared to a turbo,' explains Manchester. 'If you start making something that's already complex and then putting turbochargers on it, you can over complicate it and impact the success of a series. With the LMP2 engine at the moment, you fit it and forget.'

'Performance window is the other thing,' adds Lovett. 'Maintaining this consistency of performance across 60 engines, each running through 80 hours of life, is a real challenge to ensure all customers get exactly the same performance. Turbocharging brings another element to that – controlling the boost very closely – which isn't straightforward. The normally aspirated approach lends itself better to very consistent performance.'

Manchester believes a V8 was the right choice for LMP2 in 2017, but also reckons that Gibson shouldn't insist it will remain that way in the future. Brittan agrees: 'Now we are widening our horizons, I wouldn't be surprised if we do something in that area [of turbos] in the next few years.'

The winner of the LMP2 powertrain contract is expected to be announced at Le Mans in June. Understandably, Gibson is not quite ready to divulge the details of its bid, which has been made alongside companies that would provide the vehicle electronics system and gearbox. However, Manchester states that Gibson has 'met all the requirements' the organisers asked for. Aside from a turbo, these include 420kW (563bhp) of peak power, a total dry engine weight of under 160kg and a brake-specific fuel consumption of under 250g/kWh. Other aspects, such as the c of g, dimensions and how a push-to-pass system might be implemented, are for each prospective supplier to provide.

Gibson was initially selected to supply engines to the next-generation LMP2 cars from 2026, when the vehicle design was based on current LMDh machinery. However, that plan was scrapped last year, invalidating the contract and meaning Gibson had to start from scratch, in accordance with the FIA and ACO's updated requirements for an all-new car.

Wider scope

Although Gibson had time to draft some ideas before the new tender was published, the final parameters were not confirmed until March of this year. This made for an extremely busy few weeks to present the details in a 300-page document and submit everything before the application window closed in early May, having been extended from the end of April.

Marcel Wulf / Focus Pack Media

Gibson expects the current generation of LMP2 cars to remain popular, despite the formula adopting new regulations in 2028

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GIBSON TECHNOLOGY

'It's a much wider supplier requirement than the current tender,' says Lovett. 'It's more akin to what we'd do with our own Zytek sportscars, where you would do pretty much everything, including sourcing the gearbox and electronics. It's familiar territory, but it will be a bigger volume. You are providing the whole system, not just the mechanical parts.'

As noted, Gibson wants to diversify its operations, but if it wins the LMP2 contract again, will that mean it remains in the same situation as today, attending to one project at the expense of others that might reduce long-term risk? There are no signs LMP2 is set to decline in popularity. The ACO's decision to keep it on the Le Mans grid has incentivised teams to keep plugging away in regional series, despite it being dropped from the FIA World Endurance Championship in 2024. Therefore, the winner of the 2028 powertrain contract is expected to have a similarly busy workload that Gibson currently manages from its Repton base, looking after customers in the European Le Mans Series, IMSA Sportscar Championship and Asian Le Mans Series.

'We have to be honest, diversification requires money,' says Brittan. 'If we're successful in the LMP2 [tender], it will bring in the revenues that will allow the organisation to invest and expand. There might be the perception that LMP2 is a pot of gold, that isn't the case. But if we aren't successful, there's a hole in our books we need to fill. I want to reduce the percentage of income LMP2 brings into this organisation by diversifying and bringing other streams in. We're being far more proactive now in looking for opportunities. Perhaps we could be accused of not seeking out those opportunities over the last few years enough. Rightly so, we've had a very strong focus on our LMP2 business. That was the right thing to do, but that doesn't mean we can't expand now, without weakening the quality and service we provide currently.'

> "I want to reduce the percentage of income LMP2 brings into this organisation by diversifying and bringing other streams in"
>
> *Mark Brittan, managing director at Gibson Technology*

Beyond motorsport

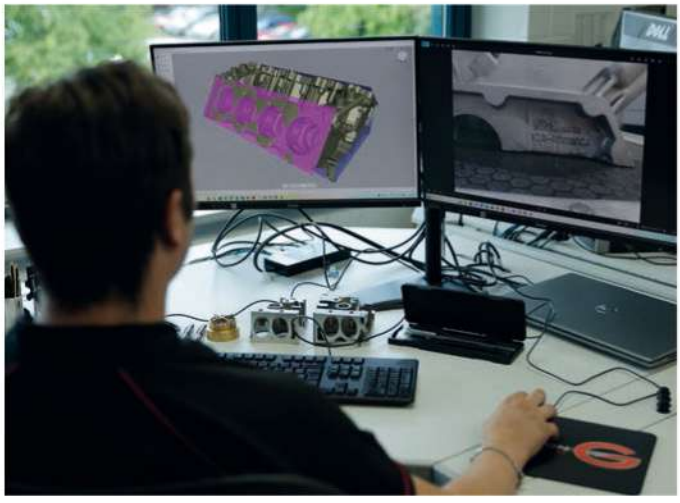
Like many motorsport companies, Gibson sees opportunities to apply its technology and engineering facilities to industries beyond racing. 'I think one of the biggest changes is that Bill used to have a saying, while we're in the paddock, business will come to us,' says Brittan. 'I'd like to flip that around and give the message that we're open for business. We've got a number of professional service capabilities internally that we can take advantage of more [and] we are now actively looking for more opportunities.'

Those services include manufacturing. Gibson is building parts for the University of Leicester's space engineering programme, as well as some other projects that are under wraps for now. The company isn't geared up to do high-volume manufacturing, so prefers to tackle projects that require lightweight, high-power components.

'Utilisation of the machine shop has historically been linked to LMP2 demand,' adds Brittan. 'With the technology we've got, there is no reason why that utilisation cannot be increased to service other customers. We have an electrical department where we make a lot of looms, we also have inspection services and design offices.'

Since its re-branding, Gibson has gained a solid reputation for reliable, powerful and noisy LMP2 engines. However, its current management know the company needs to adapt to a changing environment. Aside from embracing turbos, they envisage a multi-faceted Gibson, similar to how Zytek balanced engine building with engine control, electric motors and chassis design during the 1990s. Standing still is not an option.

Gibson Technology



As part of its evolution, Gibson is trialling more remote support for customers to save on sending a trackside engineering team to every race

Gibson Technology today

Gibson Technology

Technicians in the sub-assembly room. Gibson has an apprenticeship programme to help encourage young engineers into motorsport

Repton is a charming, historic village in south Derbyshire, once the capital of the Anglo-Saxon kingdom of Mercia. Just down the road from the thatched cottages is an inconspicuous turn-in to a driveway rising through tall, thick trees that conceal a cutting-edge motorsport engine factory.
The location of Gibson's headquarters, set back from the main road, is deliberate to allow overnight dyno tests to be conducted without impairing village life.

Zytek rebuilt the Repton facility in the 1990s to service Formula 3000 engines, but there is room for further growth. Indeed, company founder and former chairman, Bill Gibson, purchased the adjacent field for that very purpose. Today, the 22,000ft.sq complex houses dedicated areas for design, assembly, manufacture, testing, procurement and customer support. Gibson Technology employs around 65 staff, a number that has grown by ten over the past 12 months in support of the diversification agenda.

Assembly and sub-assembly are housed in one room, which on *Racecar*'s visit was busy preparing for the 24 Hours of Le Mans. New ancillary parts such as cylinder heads, scavenge and water pumps, intake systems and drive-by-wire motors are built and fitted here. Some parts are developed in conjunction with partner companies, such as the throttle control motor, for which Gibson liaised with Maxon Motor.

From assembly, a corridor leads to three rooms housing a dyno each, one eddy current and two water brake. Tests exceeding 50 hours have been recorded, but typically the dynos are reserved for rebuilt LMP2 engines (a standard engine rebuild takes between 70 and 80 hours). Each one goes through the same cycle: a one-hour session throughout the speed range, followed by a simulated qualifying lap of Le Mans.

The manufacturing area contains several large CNC, tooling and milling machines to create the engine's metal parts. Additive manufacturing is also used, but primarily to assess prototype designs. Three years ago, Gibson added a five-axis machine that slashed the manufacture time of a cylinder head from 40 hours to around 23. That freed up manufacturing capacity, which Gibson will need as it seeks to diversify its activities.

The company also has an electronics department where technicians build wiring harnesses for each engine, connecting circuits for the engine's various sensors. Some component parts here are bought in, such as ignition coils, but most of the engine is designed and built from scratch. And, in a neat salute to its past, Gibson Technology fuses a Zytek badge onto each engine block it produces.

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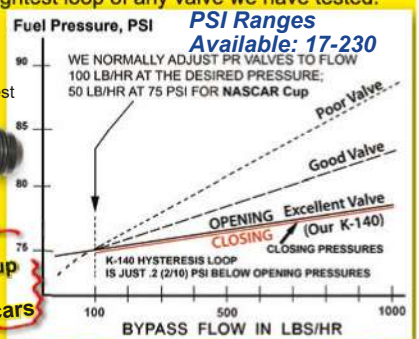

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Milestone cowboy

Pascal Vasselon masterminded Toyota's recent Le Mans wins, but had to navigate a rough road to victory

By Andrew Cotton

Toyota's first Le Mans challenge under Vasselon was in 2012. The TS030 Hybrid was only supposed to be in development that year, but the programme was accelerated and got off to a flying start

Toyota celebrates 40 years of competition at Le Mans in 2025, though it is only relatively recently that the team has found success in the 24-hour race. The Japanese manufacturer's Le Mans story began in 1985 with the TOM's-run 85C, a turbocharged Group C car that finished 12th on its debut. Dome followed in 1986 before Toyota-branded cars ran through to 1990.

The spectacular TS010 raced in 1992 and 1993 with a 3.5-litre engine designed to Formula 1 rules at the time. The Supra model represented the marque in 1995 and 1996, before the TS020, also known as the GT-One, entered the fray in 1998 and 1999. At the latter event, Toyota came its closest to winning, prior to the current era, only for a series of unfortunate events to blunt the team's charge to the flag.

After that, there was a hiatus as Toyota Motorsport GmbH (TMG) turned its hand to Formula 1, building its factory in Cologne, Germany into one of the leading motorsport engineering facilities in Europe.

Enter Vasselon

The F1 project came to a close after the 2009 season, and there was a short pause before the decision was taken to return to Le Mans. The green light was given in 2011 and the programme was put in the hands of Pascal Vasselon, who joined Toyota from Michelin in 2005. As technical director, it was down to the Frenchman to try and make Toyota only the second Japanese team ever to win the greatest endurance race of them all.

Work on the Toyota TS030 Hybrid started in 2011, with the intention of testing the car through the 2012 season, but the sudden and

Vasselon was senior general manager, chassis on Toyota's F1 project until it was stopped in 2009, at which point he switched to endurance

From tyres to tech chief

Pascal Vasselon first came into the motoring world through Renault, as a suspension engineer, specialising in four-wheel-drive systems. Understanding the importance of the tyre in the handling set-up of a car, the move to Michelin was a logical step. He joined the French company as head of vehicle dynamics and then moved to the racing department to better understand the complexities of tyre management. Vasselon went on to become a tyre developer for the DTM and worked as a tyre designer between 1992 and 1995.

In that time, he was covering Super GT in Japan, where Michelin fought against Bridgestone, and was also active in the British Touring Car Championship. By the time Michelin returned to Formula 1 in 2001, he was the company's F1 director and took the wealth of tyre information he had amassed with him to Toyota when he was hired in 2005 as head of development and research, chassis. He was then instrumental in the Japanese team's development until its F1 programme stopped in 2009. From there, it was only a short hop into endurance racing, where his tenure began as Toyota's technical director.

Despite the TS030 putting in strong performances throughout the first two seasons, and showing blistering pace, the team was unable to translate that into a win at Le Mans in either 2012 or 2013 (shown)

By 2014, the TS040 Hybrid had become a dominant force, and Toyota was world champion, though still without an outright win at Le Mans. The car led the 24-hour race in 2015 (shown), until an FIA sensor failure proved its undoing

> While success came to the team in other races, overall victory at Le Mans remained elusive

unexpected withdrawal of Peugeot from LMP1 that year meant Toyota had to accelerate its introduction to mid-season. There was no Balance of Performance system to rely on, and very few technical limitations compared to today.

'During 2011 we started to develop the LMP, so we had to have a sort of secondary programme for some years,' remembers Vasselon. The team built a GT version of the [Lexus] LFA, but officially that never raced, although quite an advanced car turned up in customer hands at the Nürburgring 24 Hours shortly afterwards.

'Quite quickly, the LMP1 programme came in,' continues Vasselon. 'We had kept all the [key] people and the motivation was incredible. We all jumped onto the little programme, we plugged in ORECA [to run the cars] and it was really pleasing to be in the team then.'

After the Formula 1 project ended, staff numbers at Cologne had dropped, from more than 1000 to just 270, and those left also had to provide engineering services to other companies. They had eight dynos, seven-post rigs and built their first wind tunnel in 2002, and then a second one in 2007. That tunnel is now being used by the Cadillac F1 team as it prepares for its debut next year.

Flying start

Despite a lack of testing, Toyota's combined engineering expertise meant the LMP1 project started off well in the reborn FIA World Endurance Championship: 'Le Mans [2012] was our first race and, after six hours, we took the lead with Nicolas Lapierre, and not by chance,' remembers Vasselon. 'So, we were immediately competitive in our first race, until we had a crash. Then, in the second race, at Silverstone, we finished second. At the third race [Interlagos] we won, and then in Shanghai we won again.'

While success came to the team in other WEC races, overall victory at Le Mans remained elusive. Even Vasselon began to wonder if the team was cursed, having shown incredible speed but, for a succession of completely random reasons, never quite being able to deliver the coveted win.

'In 2014 we were dominant, and became the world champions [with the TS040 Hybrid],' notes Vasselon. 'We were leading Le Mans by two or three minutes and were managing the pace, but then at one o'clock the call comes that we had a problem with the FIA [mandated] sensor, and they asked us to repair it. We decided to pit to have a look. We know now that a loom had melted and it was the first one you could see on the dashboard

The troubles continued in 2016. The new TS050 Hybrid was spectacularly quick, but broke down on the final lap at Le Mans. Despite finishing, the car was disqualified as its last lap exceeded time

> Porsche and Audi outperformed the TS040s comprehensively [in 2015], and Toyota's response was a change to its processes in Japan

Toyota fielded a three-car effort in 2017 but, once again, was thwarted by a succession of unfortunate incidents

but, as soon as the car was in the pit lane, the problem disappeared. When you are leading the race by two minutes, and the problem disappears, you don't even hesitate, you just carry on.'

The car retired from the race just after half distance, Kazuki Nakajima pulling to the side of the road at Arnage with an electrical failure. With the team's sister car having been caught up in an accident in heavy rain within the first 90 minutes, that brought Toyota's winning streak in the WEC to an end and added yet more pressure onto the team.

Process change

For 2015, Toyota soldiered on with an old engine, and a super capacitor hybrid system that proved to be less competitive than was hoped. Porsche and Audi outperformed the TS040s comprehensively that year, and Toyota's response was a change to its processes in Japan. There, the younger engineers were tasked with experimenting and carrying out early development of engines, while the older engineers used their experience to finish the engines and prepare them for racing.

After the 2015 struggles, the younger engineers were elevated to work alongside their experienced colleagues, accelerating the development of a new engine and hybrid system. The resulting TS050 Hybrid was spectacularly fast but, as has now become an infamous story in Le Mans history, broke down when leading on the last lap in 2016, again with Nakajima at the wheel. Although it finished the race, it was not classified as the final lap took too long to complete.

With a three-car effort for the first time, 2017 conjured up its own unique dramas. 'We had three cars able to win, and then we had one real quality issue on the number eight car, where a bolt undid itself,' recalls Vasselon.

The Kamui Kobayashi incident remains extraordinary. He was given the thumbs up at pit exit by another driver, only to jump the red light. 'There is a rule that the human indicator has priority,' says Vasselon. Kobayashi went, but burned out his clutch and retired. Since that incident, it has been forbidden for drivers to wear the same colour gloves as marshals.

After contact with a lapped car, the third Toyota suffered a cut tyre, which damaged the electronics, and also retired. 'I was so upset that I bought a replica of the GT40 chassis that won in 1968 and 1969,' laments Vasselon today.

In that 2017 race, both Toyota and Porsche suffered hybrid failures. Toyota had no option but to change both the battery and the MGU, while Porsche took a risk and only changed the MGU, going on to win the race. Once again, Toyota's hopes of victory at Le Mans were dashed.

'We had gone for better integration that was lighter,' recalls Vasselon. 'You cannot design the car in case it fails, because I believe that's the wrong way to do it, but then sometimes you pay for that.

'You can have compromises, but then you have a car that is slow. We did not change the philosophy because we believed we had a good car, and did not need to repair everything. Many people make decisions because something is wrong, and think maybe it will happen again, but the question is – is it *likely* to happen again? In most cases, the answer is no. Probability as a principle of designing a racecar makes a lot of sense.'

> "Probability as a principle of designing a racecar makes a lot of sense"
>
> *Pascal Vasselon*

Fail safe approach

Following the withdrawals of Audi in 2016 and Porsche in 2017, Toyota stood alone in 2018 and finally took the win at Le Mans that had eluded its team for so long.

It would be unfair to say Toyota only won due to lack of factory opposition as it beat the previous year's total distance, and had a totally new approach to testing. This time, the team started by testing the car in failure modes, even going as far as sending its new star driver, Fernando Alonso, out on three wheels to ensure the car, and the team, could cope with such an eventuality.

'The performance of the car was more stabilised at that point, so it was the moment to give a lot of time and space to operations,' explains Vasselon. 'We started to sacrifice some running time just to practice fake failures, like running on three wheels. Doing that gave a lot of confidence to the team because, after so much preparation, we were somewhat confident about being able to manage.'

That breakthrough win at Le Mans was followed up by further victories in 2019 and 2020, before the introduction of a new car under new regulations in 2021. The Toyota GR010 Hybrid was the first of the new Hypercars and its debut at Le Mans exposed a fundamental flaw. A breather pipe out of the fuel tank, taken from the LMP1 model, was slightly too small and, after extended periods of running, it caused the tank to collapse in on itself, debris lodging in the fuel pumps and filters. The drama started at 7.20am at Le Mans, both cars suffering the same issue.

'It was unbelievable engineering,' says Vasselon, 'and amazing for the drivers to be able to race between 7.20am and 4pm with this problem, switching off the [fuel] pump six times a lap.' It was perhaps the hardest won of Toyota's five consecutive victories.

A further win in 2022 followed but, for the next two years, it was Ferrari's turn to prevail amid increased manufacturer participation in the top class. Meanwhile, Vasselon stepped back from his role as technical director of the race team, giving way to David Floury, who joined from ORECA, having worked under Vasselon for many years when the French organisation had a partnership with Toyota.

Abrupt end

This leadership change was being gradually arranged in the background for a while, but then Vasselon was suddenly ousted from his role in January 2024, the timing rather abrupt and unkind given his obvious success with the team. 'It was planned since we recruited David in 2021,' says Vasselon magnanimously. 'Usually at 60, people are expected to step back to coach the next leader. This is something that is very general at Toyota, so that was the end of it.

'Secondly, after so many years in racing, there had to be some point where I asked if I was still prepared to stay in motorsport? I was fully happy with the perspective, and I really enjoyed the last years [of racing].'

Vasselon is now looking to formulate Toyota's powertrain strategy going forwards, using his knowledge of racing as a test bed for hydrogen, but also hybrid engineering. He remains in close contact with the WEC team, and fully aware of the current issues it faces, but leaves technical affairs under Floury's direction as Toyota seeks to return to the top step of the Le Mans podium.

The DD mystery

Jenson Button won the 2009 Formula 1 World Championship with Brawn, having established an early lead in the standings thanks in part to the now famous double diffuser design, but Toyota also had one and believes that it was they who ensured it was legal before competing with it.

'What I am sure about is that we were the ones making it, [in the eyes of FIA director of Formula 1] Charlie Whiting,' remembers Vasselon, who led the chassis development of the Grand Prix car. 'Charlie was very smart, and came to the conclusion we had found something very clever. But, when you find a loophole, he didn't take it personally. In fact, when we went to [the FIA Court of Appeal] it was Charlie who won it for us. What he said had a strong weight in the court. So, I'm sure we were the ones making it.'

In 2018, the stars finally aligned and Toyota took the win at Le Mans it so deserved. That was the first of five consecutive victories

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Design for life

Mobil was involved in the first design phase of Porsche's 963 prototype, and helped to define some of the cooling targets, but it wasn't all plain sailing

By* Racecar *staff

Porsche and Mobil have worked together for over a quarter of a century now, and the technological partnership has been active in numerous race series, from Porsche Supercup to Formula E and the World Endurance Championship

Designing a racecar from scratch means working with partners from an early stage. Porsche's 963 LMDh prototype may have relied on the Multimatic platform that is available for sale, but the Canadian company worked to Porsche's design brief to create the chassis to carry the German manufacturer's 4.6-litre twin-turbocharged V8.

Key among the initial design parameters is heat rejection numbers, from the engine and the hybrid system, which is mounted at the rear and is spec across all LMDh cars, along with the Bosch MGU and battery from Fortescue Zero. Specifying the cooling requirements means sizing the radiators, which carries with it an aerodynamic (and weight) impact, so it was important for Mobil to be involved in the design phase with its lubricants from the beginning.

'Sometimes, OEMs spend years developing a new engine and then, all of a sudden, realise they need oil,' says Tobias Klande, Mobil's head of technology solutions, drivetrain. 'The engine has this problem, can you fix it somehow? It's possible, but ideally you should start from scratch, or at least very early, with the manufacturer to know what the weak points are and then develop for them.'

> The Hypercar class is different in that it is performance balanced, both aerodynamically and in terms of power output… which is why being involved during the design phase is so important

Performance plan

Establishing the temperature ranges in which the components work is the first step, but then the car also has to perform as planned. The early development of the LMDh hybrid system was far from straightforward and, at its first race, the 24 Hours of Daytona in January 2023, one Porsche stopped on track with a failed gearbox, one of the spec parts supplied as part of the LMDh rule set.

'The first race with Porsche was something to forget,' admits Klande. 'One of the cars had a problem with the high-voltage battery system, or cooling system, and the other had a problem with the gearbox. So, the first real test on the track and you see the gearbox [broken] with oil all over the track. I wondered if there had been a mistake in the oil.'

As it transpired, it wasn't the oil that caused the issue at Daytona, and the car has been developed since, to the point that it won the 2024 FIA WEC Drivers' Championship, and in the current season is dominating the IMSA Sportscar Championship.

Mobil has a long association with Porsche, enjoying a partnership of more than 25 years. In this role, it has been involved in development for the Porsche Supercup, Carrera Cup and FIA Formula E World Championship, where efficiency is paramount.

Cooling requirements are different in LMH and LMDh, the latter using a spec hybrid system that must operate within a thermal range specified by the series organisers. If a car goes outside those parameters, it has its power output reduced

> “The aero window [in endurance] means you cannot blank off inlets. So over a season, or over a race, you have far more temperature spread for an oil than in any other race series”
>
> *Stefan Moser, LMDh technical director at Porsche*

Lubricant development never stops, though advances tend to be incremental now rather than groundbreaking

The Hypercar class is different in that it is performance balanced, both aerodynamically and in terms of power output. Therefore, unlike the Formula E partnership, reducing friction in the gearbox once the car is designed is not a primary focus, as in sportscars the power output is measured at the wheel. Improving the cooling requirements also doesn't make a great deal of difference as the aerodynamics are similarly tightly controlled, which is why being involved during the design phase is so important.

Temperature spread

'There are different oils in the car and, in these cars, temperature is thermostat controlled,' notes Porsche's LMDh technical director, Stefan Moser. 'The extreme cool [conditions] are not much of a problem, but still low compared to a Formula E or Formula 1 race. And you still have to manage 24 hours so, whatever the ambient temperature, you have to deal with it.

'In Formula E or Formula 1, you don't have to operate in an aero window, so you can blank off parts, but the aero window [in endurance] means you cannot blank off inlets. So over a season, or over a race, you have far more temperature spread for an oil than in any other race series.'

In BoP formulae, the primary focus in lubricant technology is efficiency, rather than using them as a performance tool

The cooling package for the hybrid systems was designed from the outset with very different requirements for the two types of cars that race in the Hypercar class. LMH constructors can integrate their hybrid unit design within the cooling system, while the LMDh car has to provide cooling to a spec system, which limits its options.

'For the spec parts, they give us a thermal range in which we are expected to run, and if you go outside that range, they turn down the power,' says Moser. 'So you have to stay in that temperature range. In LMH, [manufacturers] can define their own hybrid system, so they can run in the thermal range that is good for the car, not just the hybrid system. That makes a huge difference.

'If you have a hybrid system that is asking for 50degC, for example, the difference to ambient is so big that the coolers are huge. It has to fit for the worst case track, but then it's over designed.'

So, while oils and lubricants may not evolve hugely during the lifespan of a prototype like the Porsche 963, the key to success is clearly involvement at the start of the design phase, ensuring the cooling and regulatory requirements are met, but also that the car is racing at its most efficient in all the conditions it has to work in.

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We (don't) have lift-off

The study of aerodynamic safety in NASCAR has been ongoing since the 1980s, yet new devices are still being investigated and introduced

By ERIC JACUZZI, CHRISTOPHER POPIELA, MIYA DUBLER

NASCAR as a sport, and a cultural icon in America, is defined by speed, sound and colourful personalities. While all tracks the Cup Series visits are demanding in their own right, the superspeedways of Daytona and Talladega are the kings of the hill in size and speed. Famous for packs of tightly bunched cars, they present a difficult challenge for NASCAR aerodynamicists to keep the racecars from taking off when they inevitably end up sideways, or backwards, at speeds close to 200mph (321.8km/h). This has been an area of research since the 1980s and continues to this day. The engineering of a new lift-off safety device gives a glimpse into the methods and obstacles involved in this type of testing.

Disruptive devices

The current Gen 7 (aka Next Gen) NASCAR has several aerodynamic devices to help reduce the odds of a lift-off event. One of the most visible, and oldest, tools is the roof flaps. When a car begins to spin, these flaps automatically deploy to disrupt the fast-moving air that is creating suction across the greenhouse area. This creates areas of high pressure in front of the flaps, which reduce lift and help prevent the car from becoming airborne. The flaps are positioned at varying angles from the car centreline to cover a wide range of spin scenarios.

Supporting the roof flaps are fixed components like the roof rails, deck fin and shark fin. These components remain stationary on the car and are aligned with the vehicle's direction of travel. The roof rails are made of aluminium and extend from the windscreen to the rear window. These are most effective when the car is at 90 degrees of yaw (sideways), spoiling lift on the leading edge of the roof.

The deck fin and shark fin are significantly larger than the roof rails and are positioned on the decklid and rear window, respectively. Like the roof rails, they function to minimise lift during a spin by managing air over the rear surfaces. Due to their larger size, and the need to maintain rear visibility, these fins are mainly constructed from clear polycarbonate.

Hood flaps are another visually obvious device that can be seen when a car is in a spin, as well as fluttering occasionally when cars are running very close together. These flaps act to relieve any increased pressure build up under the bonnet (hood), and so act in a similar way to the wheelarch cutouts above the tyres that are mandated for prototypes, including Hypercars.

In addition, the arrival of the Gen 7 platform in 2022 saw the introduction of a novel device called the diffuser flap. This becomes effective when the car is turned through 180 degrees ie running backwards, and is triggered automatically by the deployment of the right-side roof flap via a cable arrangement. Its job is to prevent increased pressure at the diffuser exit, which was an area of concern upon initial testing.

All of these elements work together to keep the racecar grounded when physics is trying to do the opposite.

Testing challenges

Lift-off testing presents aerodynamicists with some unique challenges that have to be addressed. Testing methodologies for NASCAR are similar to normal aerodynamic development, primarily relying on computational fluid dynamics (CFD) and then validation in a full-scale wind tunnel. While the use of scale wind tunnel models does allow for yawing perpendicular to the road surface, there is still the challenge of going to full scale with confidence, given the possible differences in model behaviour vs reality.

Loads are measured in the three usual axes, but some minor changes allow us to have more insight into the actual lift-off performance. We use the rolling and pitching moments to calculate the right side and rear lift coefficient. This coefficient then goes into a lift calculation to back solve at what speed the lift would equal the weight of the vehicle on that side. Hence why in NASCAR lift-off is usually discussed in terms of speed (mph).

Wind tunnels capable of this type of testing are few and far between, due to the extreme yaw range required, typically zero to 180 degrees in either direction. They also need to be sufficiently large test sections to be able to fit a full-size car. NASCAR has used several wind tunnels in the past, but currently is using General Motors' Aerodynamics Laboratory (GMAL) tunnel in Warren, Michigan. This facility is a closed jet wind tunnel with a five-belt rolling road system, although that facility is not utilised in this application, as will be discussed later in the article.

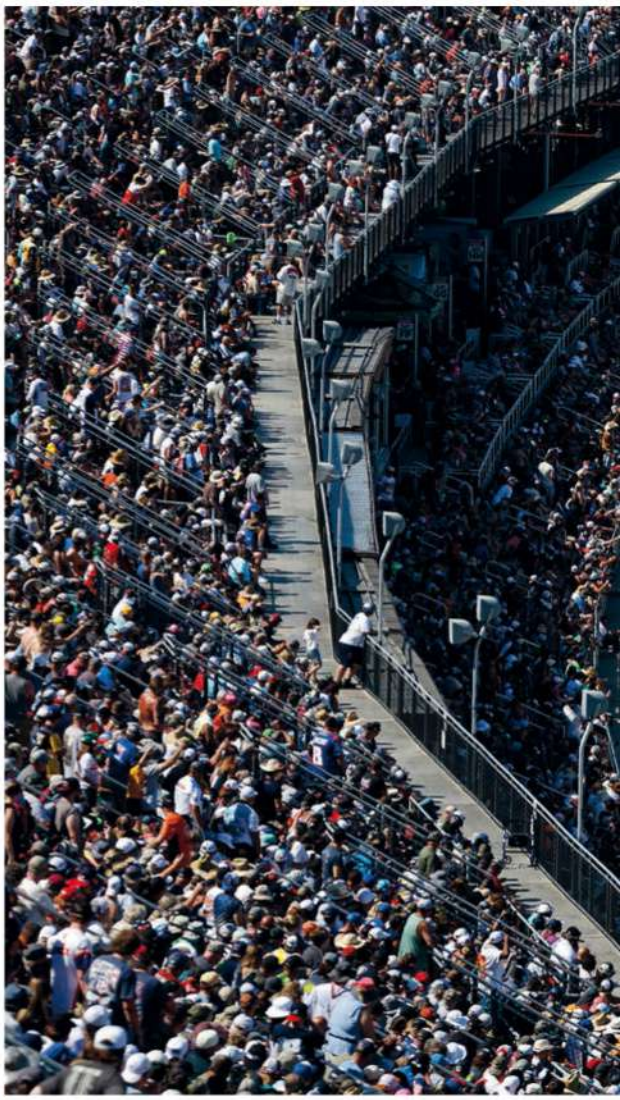
Speaking of rolling roads, this is where one of the key issues arises – the boundary layer. In a rolling road wind tunnel, road speed and wind speed are equal, giving a correct approximation for a car moving over the ground. Nearly all tunnels of this sort have the road fixed on the turntable, moving in unison with it as the turntable yaws. This means that at 90 degrees of yaw, the rolling road itself is perpendicular to the flow direction, which doesn't replicate the condition we are testing for.

The second effect of the wind tunnel is on the outer body flow. Particularly in an open jet wind tunnel, the jet of air exiting the nozzle encounters a large blockage when the car is sideways. This leads to differences in the angle at which the air is approaching the car and how it deflects over it. We know this by modelling the wind tunnel environment (walls, nozzle, collector and floor) in CFD and comparing it to the unconstrained domain.

In addition to the changes in incidence over the top of the car, there is a re-circulation zone that forms in front of the vehicle when modelling the wind tunnel vs open domain.

Initial concept

Early in the development of Gen 7, NASCAR started its analysis of the car's lift-off properties from a blank slate. Starting with CFD, the vehicle was continuously studied as



Harrison Burton's Ford Mustang demonstrates all of the current Gen 7 lift-off safety devices during a spin last year. The roof, bonnet (hood) and diffuser flaps all operate automatically

Getty Images

The closely packed bunches of cars that are a feature of NASCAR's superspeedway events make aerodynamic safety in the event of a spin a real challenge

components were added to it, including roof rails, roof flaps etc. Making improvements is a matter of eliminating low pressure on the body surfaces and reducing high pressure on the bottom of the car. One section of the car that was found to consistently generate lift was the a-post area.

At the initial lift-off wind tunnel test, conducted at ACE Climatic Wind Tunnel in Oshawa, Ontario, the NASCAR team experimented with adding a small wicker to the windscreen edge. This proved to be very effective but, due to the shape of the windscreen, the wicker was not aligned with the flow direction when the car was travelling forward normally. This idea was re-visited in 2024 at the GMAL tunnel, where a fin on the windscreen was tested (see image on p72). While unusual to look at, the revised device proved effective and, more importantly, aligned with the car's direction of travel, so as not to create any unintended issues.

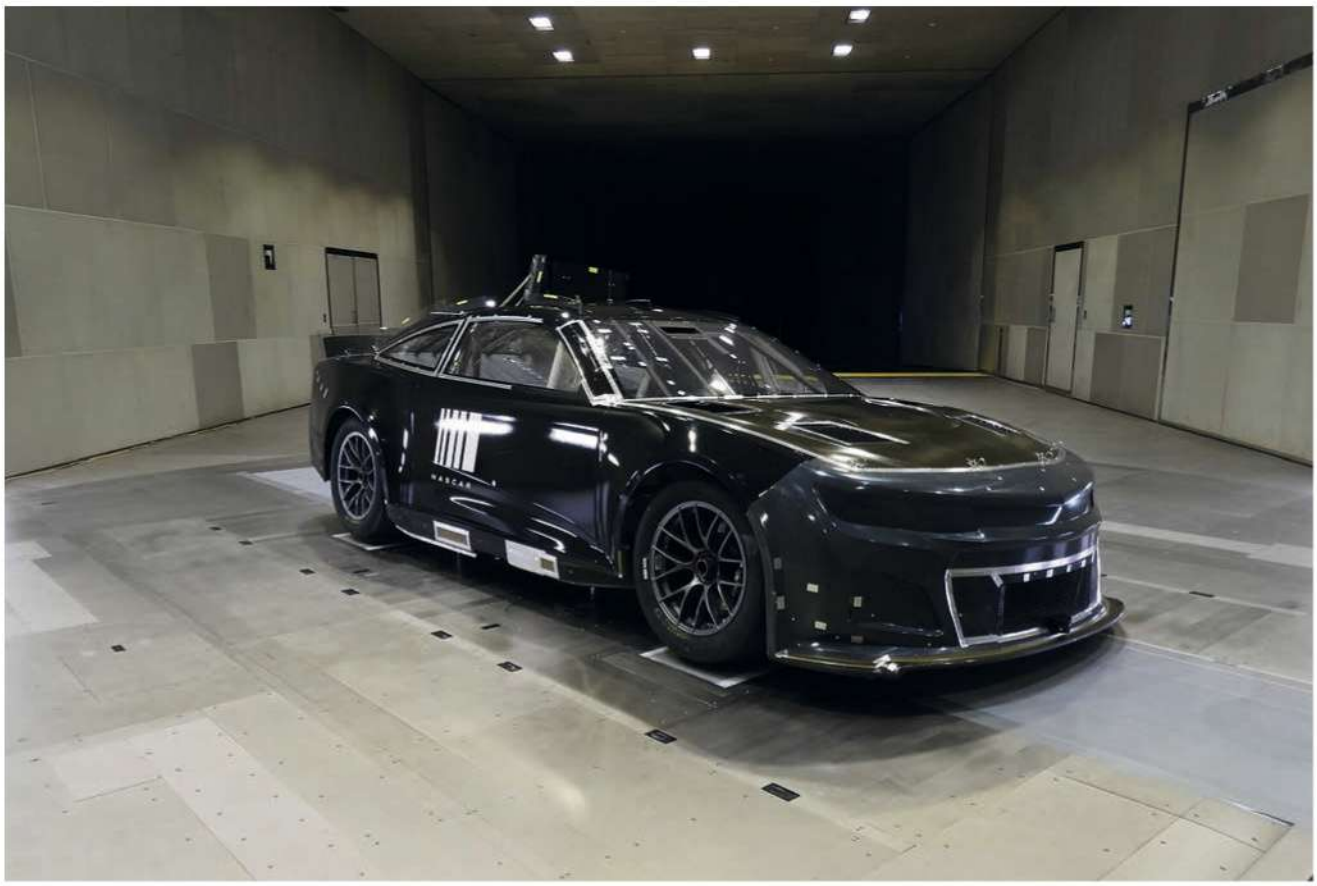
Visual impediment

However, after consulting with drivers, there was concern that the fin would be a visual impediment on track, so it was back to the drawing board for the next concept.

In an ideal world, any lift-off device should 'disguise' itself into an existing feature of the car. The roof flaps, hood flaps and diffuser flap, for examples, are all built into the body panels and hidden from sight until they deploy. The windscreen fin, on the other hand, while it performed well in the wind tunnel, was a very visible addition.

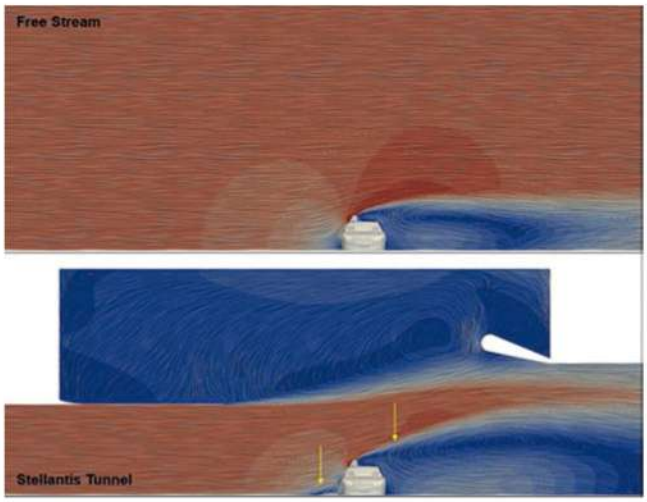
Making [aerodynamic safety] improvements is a matter of eliminating low pressure on the body surfaces and reducing high pressure on the bottom of the car

Generic Gen 7 body with its aerodynamic lift-off components highlighted: roof flaps (red); hood flaps (purple); roof rails (green); shark fin (orange); deck fin (blue) and diffuser flap (pink)



There are very few facilities capable of providing the environment to test a full-size NASCAR in yaw. General Motors' Aerodynamics Laboratory wind tunnel in Michigan is one

In race conditions, the flap will be deployed during a spin and controlled by a tether to prevent it from folding onto itself



CFD modelling of the wind tunnel environment vs open domain. Note the difference in the angle of incidence over the roof and recirculation zone ahead of the door

The a-post flap came about as a deployable version of the windscreen fin. Conveniently, it also provided superior aerodynamic performance to the fin, while at the same time being a nearly invisible addition to the car when not deployed. The new flap also provided an opportunity to apply the same concept on the left-hand side of the car without obstructing the driver's view.

Tunnel tests

After verifying the a-post flap's performance in CFD, the next step was returning to the GMAL wind tunnel. During data collection, the a-post flap was held in a fixed position and adjusted through various angles to determine the optimal deployment position. In race conditions, the flap will be deployed during a spin and controlled by a tether to prevent it from folding onto itself. It opens when the vehicle is in a yaw situation between 45 and 180 degrees.

Collecting data across these varying yaw angles provided insight into the flap's effectiveness throughout the phases of a spin. The test was deemed successful and the new device proved to be even more efficient than the windscreen fin.

Once the concept was proven in the initial wind tunnel tests, the development process moved on to evaluating more practical considerations. Can the design, and the proposed materials for its construction, withstand a full-speed deployment at nearly 200mph? How will the flap behave in these conditions? And what about unanticipated interactions on track, often caused by a car's proximity to another vehicle, or the wall?

On-track testing is the best way to address these concerns, but it's still not the same as having a full field of 40 cars at race speed, and the aerodynamic chaos that creates.

One other concern that cannot be overlooked is that of accidental deployment of a safety device. This can range from a minor nuisance to potentially impacting a car's performance. All these issues must be addressed to have confidence in a real-world roll out of any new device.

Track testing

An initial design was taken to Michigan International Speedway (MIS) during a Goodyear tyre test in early April 2025. While not a superspeedway, top speeds at MIS are sufficiently high to mimic conditions expected at Talladega or Daytona. The a-post flap operated similarly to the hood and roof flaps that are held down with magnets,

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The a-post area of the car can experience pressures twice as low as the hood flap region when travelling in a straight line, so it quickly became clear magnets alone would not suffice

deploying only when the pressure differential is great enough to exceed the magnet's pull.

Single car and group runs revealed some lifting and fluttering of the flaps at speed. The a-post area of the car can experience pressures twice as low as the hood flap region when travelling in a straight line, so it quickly became clear magnets alone would not suffice.

It was decided instead to move to a mechanical latching system, as well as strengthening the flap against the torsional loading it was experiencing. A mechanical latching system is utilised on the diffuser flap, triggered from the deployment of the right-side roof flap. This remarkably simple system has proved very effective, so a similar approach was taken to the new a-post flap. Straight-line wind tunnel testing in the near future will ensure these various issues have been addressed, and overcome.

As a final validation step, a component-level test at a smaller, but still 200mph capable tunnel, is required. After some searching, Kirsten Wind Tunnel at the University of Washington was selected and booked for a July test. There, NASCAR will deploy the new flap at various speeds approaching 200mph and measure loading and pressures on the device to ensure it can withstand the conditions it will be exposed to.

Rolling out

Rolling out a new development such as this mid-season is never ideal but, when it comes to safety advances, NASCAR will move with appropriate speed to implement the component on its racecars. There are numerous factors to consider before doing this, including the racing schedule, the track types of those races and the manufacturing lead time of the new components. NASCAR meets with the technical leadership of OEMs and teams frequently to update them on any such changes that are coming and to solicit feedback. The organisation also regularly meets with drivers at the various tracks for the same purpose.

The new flap is set to make its race debut at the second Daytona race of the season in late August 2025. Earlier that month, teams will receive their first sets of components from NASCAR, giving them several weeks to install them, troubleshoot and have any questions answered. To meet this deadline, production of the new a-post flaps, and the necessary hardware, is currently under way.

Hopefully, this was an informative 'peek under the hood' of how NASCAR develops and implements new aerodynamic safety devices, and the challenges that go with it.

One thing is certain: the job of improving safety is never done, and NASCAR will continue to innovate in this important area of racecar design.

Shown here in late 2024 is the original design for the windscreen. The fins used for testing in the wind tunnel are aluminium for ease of modification, but any such devices are made from clear polycarbonate when implemented to avoid impairing driver vision

Prototype wind tunnel implementation of the new a-post flap. Again, this version is made from aluminium, while the production version is constructed in carbon fibre, with some slight revisions made to the mounting and mechanical latching system

Dr Eric Jacuzzi is VP of vehicle performance at NASCAR; Christopher Popiela is senior director of aerodynamics at NASCAR; Miya Dubler is an aerodynamics and CFD engineer at NASCAR

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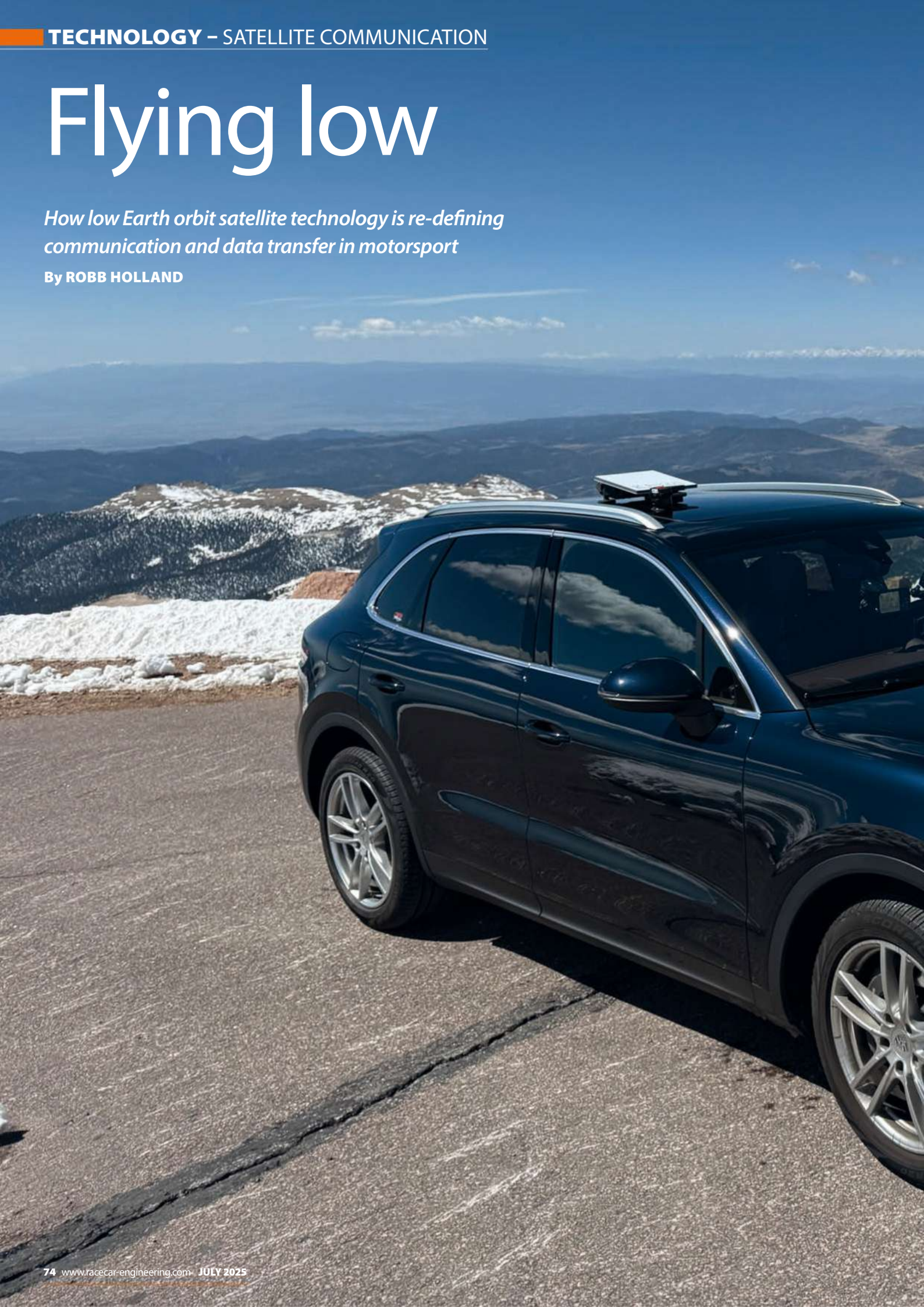
Flying low

How low Earth orbit satellite technology is re-defining communication and data transfer in motorsport

By ROBB HOLLAND



Our sport has come a long way from the days of hanging a crew man over the pit wall with a chalkboard to give split times. Nowadays, even club teams have some degree of access to advanced radio communications, telemetry and even streaming video. However, with the proliferation of low Earth orbit (LEO) satellite constellations – of which SpaceX's Starlink is the most well known – a new generation of connected racecar has arrived. This technology is giving competitors at all levels of motorsport access to data bandwidths that would have been the envy of Formula 1 teams a couple of decades ago. Moreover, it has the potential to offer competitors in remote events that have historically lacked any degree of connectivity (think Baja 1000 and Dakar Rally) new pathways to stream telemetry and onboard video, in real time, back to their team in the pits, or virtually anywhere across the globe.

One event that will see substantial benefits from this expanding connectivity is the venerable Pikes Peak International Hill Climb. One of the world's great motorsport events has been, to a certain extent, left out in the cold, as getting a live broadcast signal off a 4300m mountain has proved virtually impossible over its 103-year history. This year, though, a handful of cars will attempt to live stream onboard video and telemetry of their respective runs. These streams will be integrated into the live broadcast feed for the first time ever, to be shown on Racer Network's live coverage of the event.

Current technology

Before we delve into this new technology, let's take a deeper dive into the current systems used in worldwide motorsport coverage, and their limitations.

Thousands of tiny antennas that work together direct and steer the signal, enabling the dish to track satellites automatically, without requiring mechanical rotation

With LEO satellites orbiting the Earth at a height of around 550km, compared with 35,000km of traditional geostationary satellites, latency is greatly reduced and throughput improved

Radio frequencies (RF) have been essential in motorsport for decades, used for everything from driver / team communication to telemetry. Operating typically in the UHF (Ultra High Frequency) or ISM (Industrial, Scientific and Medical) bands, communication and telemetry systems use secure, low-latency radio links to transmit voice and data continuously during a race.

RF signals have several limitations though. Primarily, RF channels have severely limited bandwidth, restricting the amount, and complexity, of data that can be transmitted simultaneously. Data such as high-resolution video streams would be highly impractical without using advanced compression techniques, or multiple RF channels.

Additionally, today's race environments are oversaturated with RF signals, from team radios, broadcast equipment, to fans' personal devices, which leads to high signal interference, degradation and even data loss, especially in densely packed urban areas such as Las Vegas, Monaco or Miami.

RF also relies heavily on a clear line of sight between the transmitter and receiver. Obstacles such as grandstands, buildings or even the car's chassis can cause signal dropouts. Teams are therefore forced to use cumbersome, high-gain antenna and signal repeaters to help overcome these limitations.

With the current ubiquitousness of 5G cellular technology, the need for these workarounds for RF's limitations has seemingly passed, but not entirely. 5G is much more than just faster 4G. With speeds ranging from 50-250Mbps (megabits per second) in low-band form and up to a staggering 3Gbps (gigabits per second) in high-band (mmWave) form, 5G cellar technology all but eliminates the bandwidth bottleneck that plagues RF, allowing low latency, high-speed transmissions for simultaneous telemetry and 4K video data streams over the same signal.

Bonded cellular

Unfortunately, for all the advantages of 5G cellular technology, it still suffers from some of the same issues that plague RF, notably line of sight requirement and signal congestion. In order to circumvent these issues, teams started moving towards using bonded cellular technology.

Bonded cellular is a method of aggregating multiple cellular network connections to create a single, robust data stream for live video transmission. The technology dynamically manages and distributes video data across available connections in real time, optimising for network conditions to prevent buffering, signal loss or quality degradation.

This approach leverages multiple SIM cards (including from different carriers) 'bonding' the various connections into one. By combining these diverse pathways, bonded cellular systems allow for higher bandwidth, greater signal stability and lower latency compared to using a single network.

Hardware encoders, such as those from Teradek, LiveU or TVU Networks, use advanced algorithms to perform error correction, adaptive bit rate control and seamless failover (switching) between networks when the primary link fails or degrades. This enables teams and series to deliver professional grade video streams with minimal infrastructure. In areas where 'phone coverage is limited, or network congestion is high, portable towers or CoWs (Cell on Wheels) can be brought in to supplement the existing network.

Enter orbit

But what if there is no available 'phone signal? This may seem inconceivable to anyone of post-millennial age, but there are actually

Low Earth orbit satellite constellations… are designed to provide high-speed, low-latency internet access across the globe, including in mobile environments like racecars

This technology has been used in off-road events for some time, allowing teams to track and communicate with competitors in remote environments where regular network coverage does not exist

quite a few places still left on planet Earth that don't have any coverage at all. Various schemes have been cooked up by competitors to overcome this, but most options were impractical, unreliable and often extremely expensive. Enter low Earth orbit (LEO) satellite constellations.

These are designed to provide high-speed, low-latency internet access across the globe, including in mobile environments like racecars. Traditional geostationary satellite systems orbit at around 35,000km in altitude, while LEO satellites, as the name suggests, operate at significantly lower altitudes, somewhere around 550km. That they are much closer to a signal's point of origin significantly reduces latency and improves throughput, making it feasible for real-time applications such as live video streaming and VoIP (Voice over Internet Protocol).

While Starlink leads in deployment scale (6700 active LEO satellites, as of May 2025) and active user base, the company is not the only name in LEO satellite systems. Eutelsat OneWeb, a UK-based provider, is building a network of LEO satellites focused on enterprise, aviation and government markets, with coverage already expanding across northern latitudes, while Amazon's Project Kuiper initiative plans to deploy over 3200 satellites to offer consumer and enterprise broadband, leveraging the company's existing logistics and cloud infrastructure for integration.

However, Starlink's advanced antenna technology makes it most suitable for motorsport applications. The system primarily uses phased array antennas, which are capable of electronically steering beams without any moving parts. The flat user terminal (commonly referred to as the dish) contains thousands of tiny antennas that work together to direct and steer the signal, enabling the dish to track satellites automatically, without requiring mechanical rotation. The system operates mainly in the Ku-band (12-18GHz) and Ka-band (26.5-40GHz), which allows for high data throughput but require precise signal targeting; something made possible by phased array technology.

Stable connections

The antennas in Starlink's user terminals use a technique known as beamforming to focus the signal strength on a particular direction, targeting a specific satellite, improving efficiency and reducing interference. Beamforming allows for faster, stabler connections even in challenging conditions such as those seen in motorsport. Furthermore, Starlink dishes can maintain connections with multiple satellites simultaneously, allowing for seamless hand-offs as satellites move overhead or, more relevant to this discussion, as vehicles move across the ground. This feature ensures continuous internet access, even in areas with only partial sky visibility.

As one would expect, off-road teams such as those that compete in the SCORE World Desert Championship (a series that includes the Baja 1000) were the primary adopters of this new technology as they compete in extremely remote and rugged environments where traditional networks are typically unavailable. Justin Marquand of Unique Componentry, a US-based firm specialising in motorsport applications using LEO systems says that Baja, and some of the rally-raid teams, are three to four years ahead of everyone else in adapting these systems to motorsport.

'The SCORE teams had very few other options for communication. They were bouncing RF signals off chase helicopters to stay in contact with their crews, but such schemes were notoriously unreliable and

Even though the systems have been proven in the off-road world over the past few years, Pikes Peak presents a completely different and unique challenge

unbelievably expensive,' notes Marquand. 'So the Starlink system, even in its early iterations, was a gamechanger.'

Marquand has come aboard as a partner / advisor with Optima Batteries to help develop and test the Starlink system for the various cars that Optima partners with that will be carrying the onboard cameras at the 2025 Pikes Peak International Hill Climb. Even though the systems have been proven in the off-road world over the past few years, Pikes Peak presents a completely different and unique challenge.

Phased array antennas

For starters, most off-road races take place in open desert where there are few obstructions. Pikes Peak, however, places a mountain in between the user terminal and the satellites, with a road that has dozens of hairpins scattered throughout its 19.99km (12.42-mile) run. Marquand was optimistic, prior to testing, that the landscape and road features would not present an insurmountable challenge to the systems. 'The phased array antennas do a phenomenal job in tracking, connecting with and switching between multiple satellites at any given moment,' he says. 'For example, the Baja trophy trucks going through a whoops section can easily be 30 degrees off access to a connected satellite, yet the Starlink system still allows continuous, uninterrupted communication. So the switchbacks at Pikes Peak shouldn't cause the system any issues whatsoever.

'The new Gen 3 systems, and the Starlink Minis, have highly accurate GPS chips embedded in their circuit boards that handshake with multiple satellites and can easily pass off signals between them. The better the GPS signal, the better it is able to lock on to the satellite.

'It used to be that on the older systems we needed to connect an external Lowrance GPS puck in order to improve tracking, but the newer generation systems are good enough that they don't need it.'

However, should there still be signal dropouts, or high error rates, Marquand has a tried and tested solution: bonded satellite: 'Most of the trophy trucks run a bonded system using multiple dishes. Chris Polvoorde's truck has probably one of the most advanced systems in motorsport today, running a PEP link router bonded ethernet connection. That gives the option of either a robust connection or a fast connection, depending on how it is bonded, which gives the team an incredible amount of flexibility, depending on the course, conditions or the team's needs at any given time.'

Mounting location of the antenna on the user terminal is crucial as there must be no obstructions to the GPS signal. Interestingly, a car's chassis can cause an obstruction, so the roof is the obvious place on a moving vehicle

Reliable power

Having the system already sorted by those with experience in some of the toughest conditions on Earth will be helpful in ensuring the Pikes Peak test cars shouldn't have any issues prior to hitting the mountain, as there will be very little opportunity to work on the system during the main event.

Marquand has several suggestions for mounting the system to ensure the best chance of success. The primary concern is making sure there is smooth, reliable power going to the user terminal. Power surges or voltage drops (such as can occur when starting the car) play havoc with the antennas, losing sync with the satellite network. 'You want direct input DC power, preferably using a solid connection such as a Deutsch connector, as this is a known failure point with the system,' he says.

Secondly, a good GPS signal is crucial, as this is what allows the antennas to lock onto the satellites, so mounting location on the user terminal is important, making sure there are no fixed obstructions. If the terminal is

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While initial testing was carried out with the Porsche SUV shown elsewhere (and a snowplough!), in the competition the technology will be fitted to this Rotek Racing Porsche 911 GT3 Cup car

Both rain and heavy cloud cover are expected to substantially impact performance in a negative way

mounted inside the car, for example, it needs to be fixed high enough that the chassis doesn't obstruct the antenna's ability to 'see' the satellites. The more satellites the antennas can lock onto, the better and more stable the connection will be.

Marquand uses the 'Obstruction' feature in the Starlink app to determine what the installed terminal 'sees'. The app can also track disruptions over time and categorise them, as well as tracking latency (ping) and download and upload speeds, allowing users to evaluate system performance.

For normal data transmission latency is not a big concern but, when integrating onboard live stream into the network, broadcast latency is more of an issue as poor switching between onboard cameras and static trackside cameras is jarring for viewers.

To avoid this, the latest generation of Starlink satellites uses laser inter-satellite links, which are optical crosslinks that allow data to hop between satellites before reaching ground stations, which helps minimise latency over long distances. Edge infrastructure routes data through a network of ground stations and edge servers to minimise back haul time to the internet backbone. A combination of all this helps reduce latency to a very reasonable 20-40ms in ideal conditions.

Final preparations

This reasonable latency and bandwidth are what will allow the Pikes Peak International Hill Climb to integrate live in-car video from a handful of competitors in this year's broadcast, including a Rotek Racing Porsche 911 GT3 Cup (992) driven by this author.

Preliminary tests, which included strapping a Starlink to a snowplough when roads became impassible, substantiated a strong connection with very few signal dropout or transmission errors. However, air conditions during testing were favourable, with completely clear skies, not something that can be guaranteed at Pikes Peak.

Both rain and heavy cloud cover are expected to substantially impact performance in a negative way. As fighting Mother Nature is fruitless, the current plan is to have the earlier cars equipped with Starlink equipment and beat the afternoon storms. If the forecast is for bad weather all day, Rotek's engineers have made provisions for a second user terminal to run a bonded system. The team will be testing this in the weeks prior to the event with hopes of developing a system that can work reasonably well in whatever conditions the mountain throws at it.

Live coverage

Tune in to the Pikes Peak International Hill Climb's live coverage on 22 June to see if the team is successful. You can also follow Rotek Racing's pre-event testing live on the Robb Holland: Unrestricted YouTube channel

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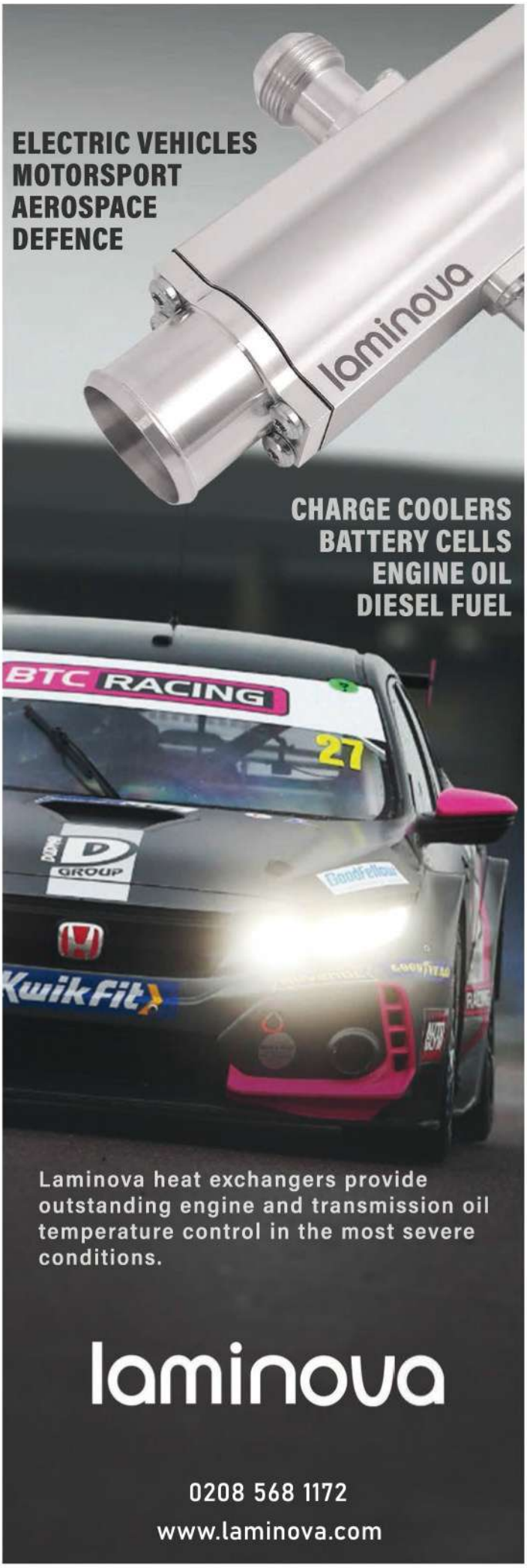
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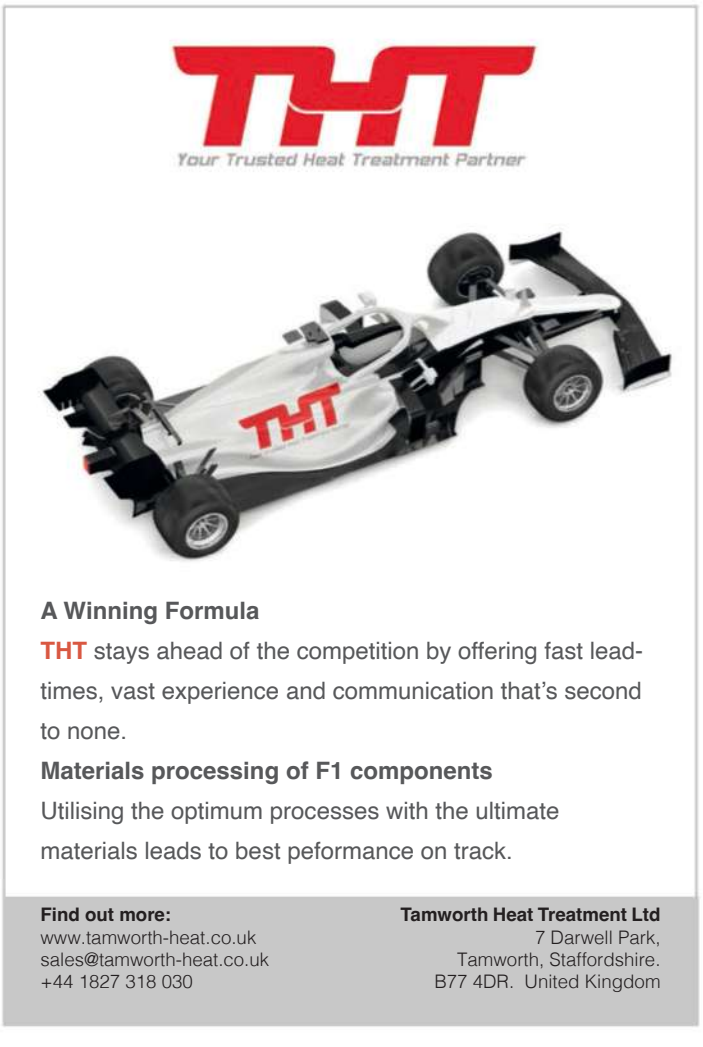
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The cycle of life

The bicycle car model – a handy approximation

By DANNY NOWLAN

One of the most useful tools for specifying a damper is the quarter-car model. It is extremely simple to understand and makes for an excellent start point for mathematically quantifying what a damper can do. It also gives you a reasonable start point for setting up your car. However, I was chatting to a no-nonsense Texan colleague of mine recently and he made the point that cars don't exist in quarters, they exist in wholes. He asked if I could have a look at this.

So, I looked at the bicycle car model and have come up with something that I hope will light the way and provide some useful food for thought.

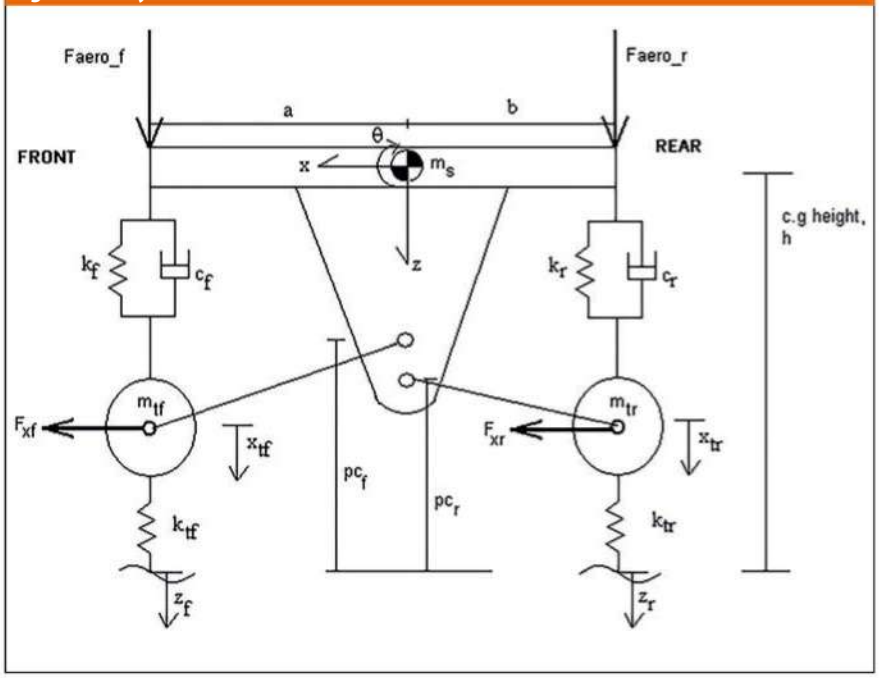
To kick off the discussion, let's review the full equations of motion of the bicycle car model. This is illustrated in **figure 1**. For simplicity, I have removed the aero and applied longitudinal forces. Don't worry, there is a method in the madness.

The terms for **equation 1** are as follows:

z = movement of the chassis down (m)
θ = pitch angle of the chassis (radians)
x_{tf} = front tyre displacement (m)
x_{tr} = rear tyre displacement (m)
k_f = front spring rate (N/m)
c_f = front damper rate (N/m/s)
k_{tf} = front tyre spring rate (N/m)
k_r = rear spring rate (N/m)
c_r = rear damper rate (N/m/s)
k_{tr} = rear tyre spring rate (N/m)
m = sprung weight mass (kg)
I_y = sprung weight inertia along the y axis (kgm^2)
m_{tf} = front tyre mass (kg)
m_{tr} = rear tyre mass (kg)
a = distance from front axle to the c of g (m)
b = distance from rear axle to the c of g (m)

It should go without saying that, since this is a bicycle model, the spring rates will be double what they are on a four-wheeled car. The exception to this statement is if you are dealing with a third spring, or monoshock. Also note that we are dealing with wheel rates here.

Fig 1: The bicycle car model



$$
\begin{aligned}
m_s \cdot \ddot{z} &= m \cdot g - k_f(z - a\cdot\theta - x_{tf}) - c_f(\dot{z} - a\cdot\dot{\theta} - \dot{x}_{tf}) - k_r(z + b\cdot\theta - x_{tr}) - c_f(\dot{z} + b\cdot\dot{\theta} - \dot{x}_{tr}) \\
I_y \cdot \ddot{\theta} &= a\cdot\left(k_f(z - a\cdot\theta - x_{tf}) + c_f(\dot{z} - a\cdot\dot{\theta} - \dot{x}_{tf})\right) - b\cdot\left(k_r(z + b\cdot\theta - x_{tr}) + c_f(\dot{z} + b\cdot\dot{\theta} - \dot{x}_{tr})\right) \\
m_{tf} \cdot \ddot{x}_{tf} &= k_f(z - a\cdot\theta - x_{tf}) + c_f(\dot{z} - a\cdot\dot{\theta} - \dot{x}_{tf}) + m_{tf}g - k_{tf}(x_{tf} - z_{bf}) \\
m_{tf} \cdot \ddot{x}_{tr} &= k_r(z - a\cdot\theta - x_{tf}) + c_r(\dot{z} - a\cdot\dot{\theta} - \dot{x}_{tf}) + m_{tr}g - k_{tr}(x_{tr} - z_{br})
\end{aligned}
\tag{1}
$$

$$
\begin{aligned}
m_s \cdot \ddot{z} &= m \cdot g - k_f(z - a\cdot\theta) - c_f(\dot{z} - a\cdot\dot{\theta}) - k_r(z + b\cdot\theta) - c_f(\dot{z} + b\cdot\dot{\theta}) \\
I_y \cdot \ddot{\theta} &= a\cdot\left(k_f(z - a\cdot\theta) + c_f(\dot{z} - a\cdot\dot{\theta})\right) - b\cdot\left(k_r(z + b\cdot\theta) + c_f(\dot{z} + b\cdot\dot{\theta})\right)
\end{aligned}
\tag{2}
$$

$$
\begin{aligned}
m_s \cdot \ddot{z} &= m \cdot g - \left(k_f + k_r\right)z - \left(c_f + c_r\right)\dot{z} - (a\cdot k_f - k_r b)\cdot\theta - (a\cdot c_f - k_r c_r)\cdot\dot{\theta} \\
I_y \cdot \ddot{\theta} &= \left(a\cdot k_f - b\cdot k_r\right)\cdot z + \left(a\cdot c_f - b\cdot c_r\right)\cdot\dot{\theta} - \left(a^2\cdot k_f + b^2\cdot k_r\right)\cdot\theta - \left(a^2\cdot c_f + b^2\cdot c_r\right)\cdot\dot{\theta}
\end{aligned}
\tag{3}
$$

The first thing to do is to take a leaf out of the quarter-car model approximation and assume the tyre spring rates are much greater than the body rates. I realise that for moderate to high downforce applications this is a bit of a stretch, but bear with me and I will explain. In this case, the bicycle model equations reduce to **equation 2**.

For the purpose of this discussion, we are also going to assume the spring and damping rates are linear. The reason we are doing all this is so that we can obtain some quick fire solutions to help light our way forward, although this time the goal is to incorporate the half-car model rather than the quarter-car model.

It should go without saying that, since this is a bicycle model, the spring rates will be double what they are on a four-wheeled car

Our next point is to re-format **equation 2** into its heave and pitch elements, This is illustrated in **equation 3**.

Note how in the heave element of the equation, the angle terms have opposing signs, while in the pitch element the heave elements have opposing signs. So, making an approximation that these elements will cancel each other out, **equation 3** can be re-written as **equation 4**.

$$m_s \cdot \ddot{z} \approx m \cdot g - (k_f + k_r) z - (c_f + c_r) \dot{z} \quad (4)$$
$$I_y \cdot \ddot{\theta} \approx -(a^2 \cdot k_f + b^2 \cdot k_r) \cdot \theta - (a^2 \cdot c_f + b^2 \cdot c_r) \cdot \dot{\theta}$$

Guess what? This is now in second order form and we can express pitch and heave as a natural frequency and damping ratio. For heave, this is expressed as **equation 5**.

$$\omega_h = \sqrt{\frac{k_f + k_r}{m_t}} \quad (5)$$
$$\zeta = \frac{c_f + c_r}{2 \cdot \omega_h \cdot m_t}$$

For pitch, this is shown as **equation 6**.

$$\omega_p = \sqrt{\frac{a^2 \cdot k_f + b^2 \cdot k_r}{I_y}} \quad (6)$$
$$\zeta = \frac{a^2 \cdot c_f + b^2 \cdot c_r}{2 \cdot \omega_p \cdot I_y}$$

Here, ω_h and ω_p are the natural frequencies for pitch and heave and ξ is the damping ratio.

Now it's time for the rubber to hit the road in the form of a Formula 3 example. The parameters for this are shown in **table 1**.

Table 1: Formula 3 car parameters

Parameter	Value
Total vehicle mass	550kg
I_y	500kgm^2
k_f	120N/mm
c_f	5000N/m/s
k_r	100N/mm
c_r	5000N/m/s
a	1.593m
b	1.107m
m_{tf}	20kg
m_{tr}	30kg
k_{tf}	240N/mm
k_{tr}	260N/mm

Crunching the numbers for our approximation, the following equation illustrates what is seen for heave.

$$\omega_h = \sqrt{\frac{k_f + k_r}{m_t}} = \sqrt{\frac{2 \times (120 + 100) \times 10^3}{550}} = 28.3 rad/s$$
$$\zeta = \frac{c_f + c_r}{2 \cdot \omega_h \cdot m_t} = \frac{2 \times (5000 + 5000)}{2 \times 28.3 \times 550} = 0.64$$

Table 2: Eigenvector and eigenvalue analysis

	1	2	3	4	5	6
Value	503.79	301.3	55.66	-16.9 +/- 44.7i	32.4	10.81+/- 27.15i
Mode	Front tyre	Rear tyre	Heave / front tyre	Pitch / front tyre	Pitch / rear tyre	Heave
Freq (rad/s)	503.79	301.3	55.6	47.8	32.4	29.22
Z	N/A	N/A	N/A	0.353	N/A	0.37

While the following shows it for pitch.

$$\omega_p = \sqrt{\frac{a^2 \cdot k_f + b^2 \cdot k_r}{I_y}} = \sqrt{\frac{2 \times (1.593^2 \times 120 + 1.107^2 \times 100) \times 10^3}{500}} = 41.33$$
$$\zeta = \frac{a^2 \cdot c_f + b^2 \cdot c_r}{2 \cdot \omega_p \cdot I_y} = \frac{2 \times (1.593^2 \times 5000 + 1.107^2 \times 5000)}{2 \times 41.33 \times 500} = 0.915$$

On the surface, then, it would appear the system is very well damped. However, when we compare this to the eigenvalues and eigenvectors of the proper bicycle-car model, a most interesting story is revealed. The results are shown in **table 2**.

The important point to note here is that, while it would initially appear we have done a good job of predicting the natural frequencies for heave and pitch, we have actually done a bad job of predicting the damping ratios.

This is a great example of how things aren't always clear cut.

If we look at **table 2** again, modes 3 and 6 act in pitch (note how mode 3 is a purely real number). That means there is no oscillatory behaviour there and it will die out immediately. So, modes 3 and 6 will play into each other. The same thing will happen with modes 4 and 5.

To confirm this, a Simulink model was set up to investigate what would happen with a step input. To illustrate, a step input of 50kgf was applied to the c of g and its response is shown in **figure 2**. When this figure is investigated, there is an initial overshoot, but the heave response very quickly settles to a steady state deflection within 0.5s.

Fig 2: Step input response of heave to a load of 50kgf

Fig 3: Step input response of pitch to a moment of 500Nm

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This is entirely consistent with a damping ratio of almost 0.7. To further check, a step input of 500Nm was also applied to the model, and the pitch response is shown in **figure 3**.

As with the heave response, there is an initial overshoot, but it is much reduced and the settling time is in the order of 0.2-0.3s. Again, this is indicative of a highly damped system, as shown by the initial approximation.

For completeness, this set-up (with zero downforce) was run through the ChassisSim shaker rig toolbox. To say the results were interesting is an understatement. The heave input results are shown in **figure 4**.

As can be seen, the heave resonant frequency of 4.25Hz compares very favourably with the natural frequency of 4.5Hz for our approximation. Unfortunately, the pitch results didn't compare as favourably. This is shown in **figure 5**.

In this case, the resonant frequency in pitch was 10Hz vs a natural frequency of 6.6Hz. However, in this scenario the resonant frequency is being driven by the unsprung mass that we have ignored.

Remember, this is only an approximation so it isn't going to be perfect, but it's a good start point, and can be refined using tools such as the ChassisSim shaker rig toolbox.

Interesting bag

What we have seen here is an interesting bag of results. Because we have ignored the effect of the tyres and have set the cross terms in **equation 3** to zero, on the surface we have committed a number of analytical sins. However, the results gained have been enough to get us in the ballpark. More importantly, we have shown that this is an analytical tool that readily lends itself to hand calculations and an Excel spreadsheet. Doing things this way will give you a keen sense of the numbers you are dealing with, rather than being at the mercy of your CAE tool of choice. That is a good thing.

For completeness, it would be prudent to contrast this with the results of the quarter-car model. The numbers for the front are:

$$\omega_f = \sqrt{\frac{120\times10^3}{112.75}} = 32.62 rad/s$$

$$\zeta = \frac{c_f}{2\cdot\omega_f\cdot m_f} = \frac{5000}{2\times32.62\times112.75} = 0.681$$

While for the rear, they are:

$$\omega_r = \sqrt{\frac{100\times10^3}{162.25}} = 24.83 rad/s$$

$$\zeta = \frac{c_r}{2\cdot\omega_r\cdot m_r} = \frac{5000}{2\times24.83\times162.25} = 0.62$$

Fig 4: Heave input results

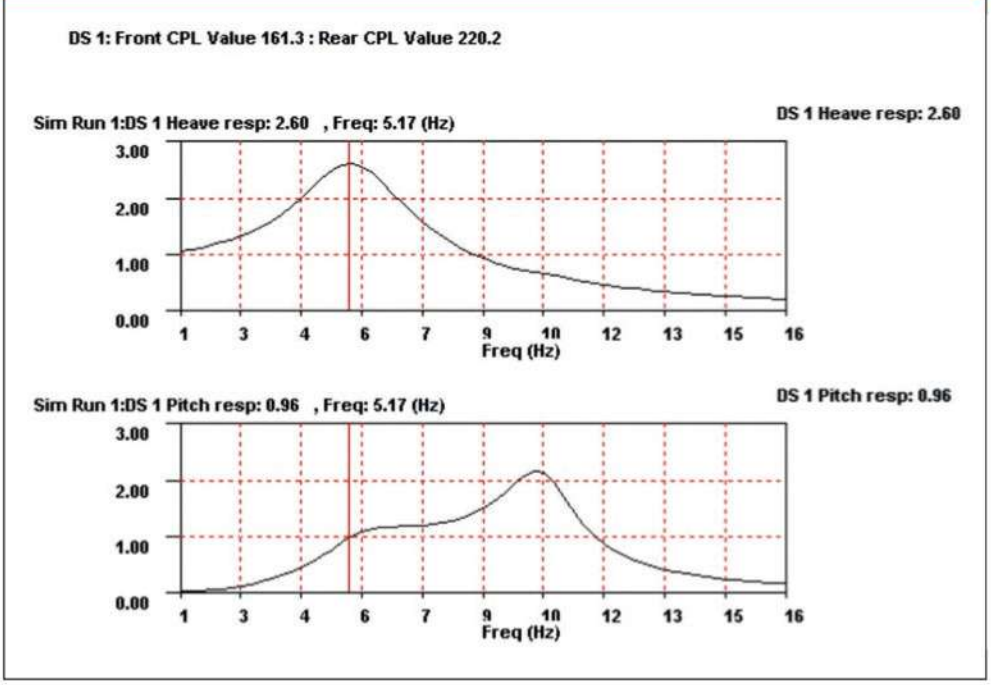
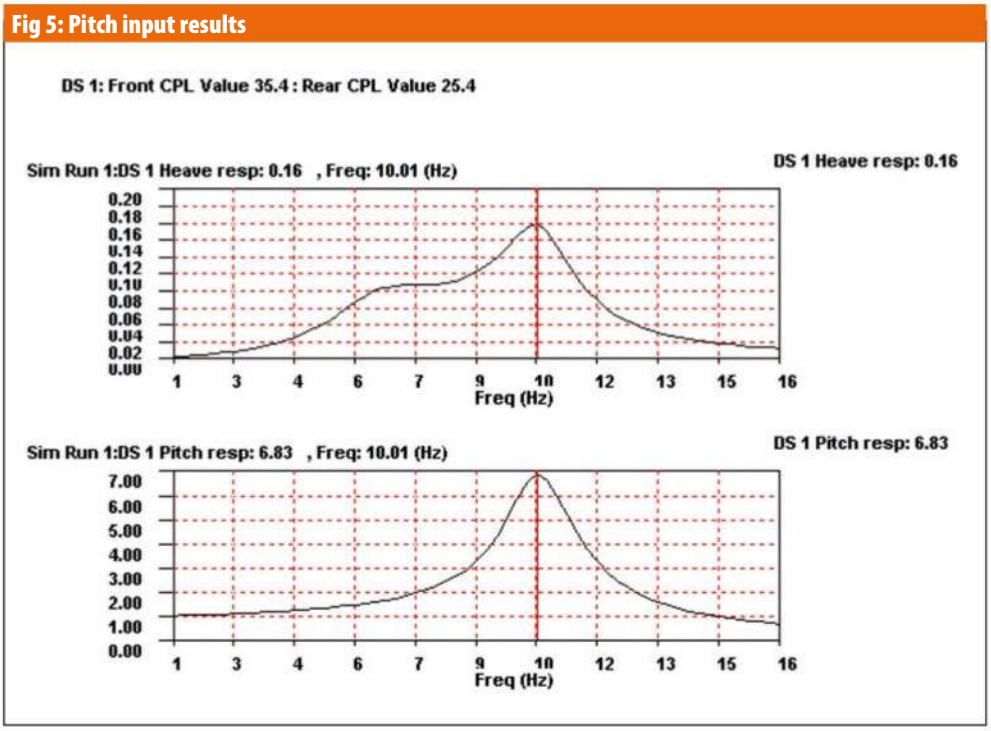

DS 1: Front CPL Value 161.3 : Rear CPL Value 220.2
Sim Run 1:DS 1 Heave resp: 2.60 , Freq: 5.17 (Hz)
DS 1 Heave resp: 2.60
3.00
2.00
1.00
0.00
1 3 4 6 7 9 10 12 13 15 16
Freq (Hz)
Sim Run 1:DS 1 Pitch resp: 0.96 , Freq: 5.17 (Hz)
DS 1 Pitch resp: 0.96
3.00
2.00
1.00
0.00
1 3 4 6 7 9 10 12 13 15 16
Freq (Hz)

Fig 5: Pitch input results



This is a most interesting set of numbers. The front-quarter car has done a decent job of predicting the natural frequency in heave and has replicated the damping ratio of the bicycle model. The rear agreement is not as good. This doesn't mean the quarter-car model is irrelevant. What it has shown is the perennial problem that exists in high-downforce cars – that there is a mechanical imbalance being dictated to by the aero.

While we have certainly cut some corners here, the results provide considerable food for thought. In particular, the correlation between the natural frequencies and the eigenvalues and step response. What this analysis technique has going for it is its simplicity and the fact you can hand-calculate the numbers. This in itself makes it worthy of both further investigation and application.

What [this analysis] has shown is the perennial problem that exists in high-downforce cars – that there is a mechanical imbalance being dictated to by the aero

McLaren Applied secure NASCAR Competition Partnership

The 2026 season will welcome a new electronic control platform from McLaren Applied.

The 2024 season marks the 13th of McLaren Applied's involvement with the series. NASCAR has been using the TAG-400N Engine Control Unit since introducing electronic fuel injection in 2012. The device has completed over **4 million miles** without any race failures.

Skylar Stamey, McLaren Applied VP of Motorsport, North America:
"Being the sole supplier to the NASCAR Cup Series is both an honor and a challenge. For over 12 years, we've continuously improved our products and services, staying committed to the local motorsport community."

TAG-510

The TAG-510 is a significant advancement from the current generation TAG-400N control unit. Modern processing and increased logging capabilities means teams and engine manufacturers will be able to fine tune their engines for even greater efficiency and log data at much higher fidelity.

EIU-510

The EIU-510 is designed to integrate with a turbo-charged, hybrid powertrain of up to eight cylinders, to deliver maximum power and efficiency.

PCU-510

The new PCU-510 digital dash display, designed for specifically for NASCAR. The display presents the driver with critical race data on a high-resolution true colour display.

Richard Saxby, McLaren Applied Motorsport Director:
"I'm thrilled that our team in the USA and UK has solidified our dedication to NASCAR. We will provide the new **TAG GT** range of systems and support for every dyno and car at every race."

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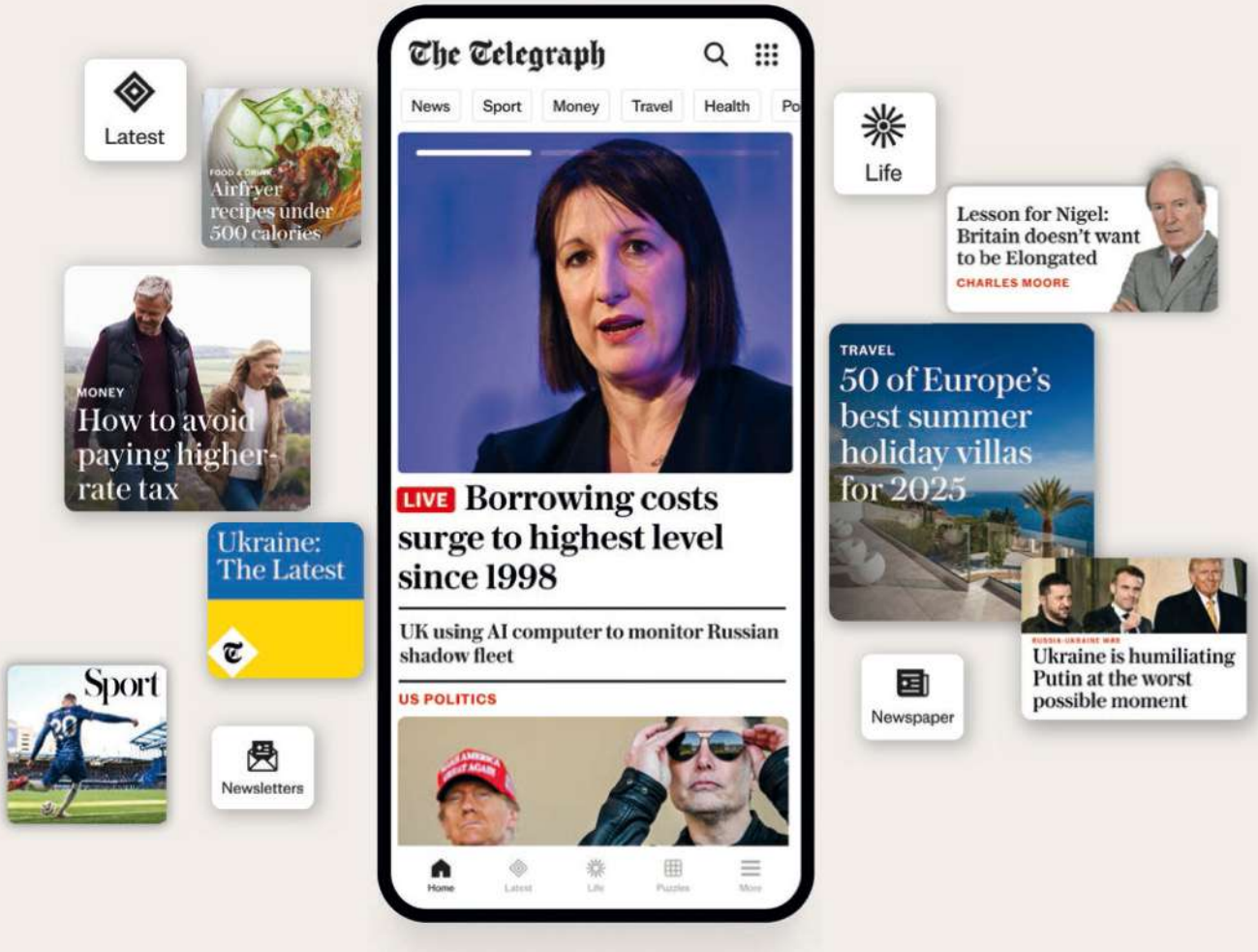

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Penske in the dock

Team Penske was again in the news ahead of the Indianapolis 500, this time for modifying the attachment of a safety structure, but there's more to the story than that

By ANDREW COTTON

The Penske team was once again the centre of attention in the build up to this year's Indianapolis 500 for all the wrong reasons. The cars of Will Power and Josef Newgarden, who was defending his 2024 Indy 500 title having also won in 2023, were sent to the back of the grid after it was found the attachment of the rear crash structure had been modified, deemed a contravention of IndyCar regulations.

The team had used a filler to blend the join and smooth the airflow across it. Although it is unlikely that such a modification would help any individual car aerodynamically, any alteration to a safety structure is illegal under IndyCar rules. The team was photographed modifying the attachment in pit lane ahead of the final qualifying session, also contravening regulations, and, according to reports, were advised that if its two drivers attempted to make their pole run laps, they would be investigated and likely disqualified.

The team elected not to continue with its final run and, initially, was told its drivers could start from the back of the 'fast 12'. However, IndyCar president, Doug Boles, and his colleagues later deemed that an insufficient penalty as, theoretically, the drivers could have qualified in that position. Instead, both cars were relegated to the very back of the field ahead of the start of the 109th running of the 500.

'The integrity of the Indianapolis 500 is paramount, and this violation of the IndyCar rule against modification to this part and using it 'as supplied,' is clear,' said Boles.

The camera never lies. Well, these days it can, but in this instance it captured the Penske team modifying the rear crash structure attachment point of its cars in an attempt to make the cars comply with the regulations, but it was too late

'For that reason, the penalty should be more than simply starting where the cars might have qualified anyway.'

Questions were asked after the event about how the cars even got to pit road, having passed technical inspection. Stories then began to unfold that the Penske cars had been using the modification for months, and even Newgarden's car in the museum features a modified attenuator fitment.

The story going around was that the tech team had simply failed to notice the alteration until notified by rival teams, but this turned out to not be the complete picture.

Power's car was the first through tech and the modified attenuator fitment was noted, but the car passed in order to get the competitors out on track as quickly as possible.

However, when Newgarden's car came through a few cars later, and the same modification was noted, IndyCar officials took action. 'When the [number] 2 [car] came through, the attenuator on the 2 was identical to the 12 and at that point in time, Rocket [Kevin Blanch, IndyCar technical director] knew that we had something we had to adjust to, or at least address,' said Boles.

Scott McLaughlin's Penske team car was allowed to start in position on the fourth row as the car had crashed and its rear wing assembly, including the attenuator, were submitted to IndyCar and found to conform.

Dallara updates

It is not uncommon for updates to be added to the Dallara chassis. It was introduced to competition in 2012, and various accidents since then have led to safety improvements to reduce the risk to the driver.

In this case, Dallara issued a number of updates to its attenuators in 2023 and 2024, with the first in May 2023 that strengthened the part internally. That, then, was updated further with a request from Dallara for teams to revert back to the 2022 design. There were a couple of slight adjustment needed, namely the wiring to the rain light and a new spec bolt to replace a tether quick pin.

The attenuator was then updated again in 2024, requiring panels to be bonded internally and externally to increase the strength of the part. 'Observing crashes from the 2023 season, we have been working on actions to further optimise the rear crash structure,' wrote Dallara in the update issued on 5 Jan 2024. 'FEA has been performed to improve the strength and retention of the attenuator during an on-track incident. This study has resulted in a re-work operation to improve the behaviour.' This re-work included the aforementioned bonding update, and work started early in January.

Prior to this update, the attenuators were a single smooth part, but the new carbon panels were a bonded composite. This is the area Team Penske cleaned up but, in doing so, broke the rules. It was a mistake to do so, but there is no gain aerodynamically, according to leading aerodynamicists. It was just tidier.

It should also be noted that other areas of the car are allowed to have modifications to fit better, as not all parts on a car as supplied are in perfect alignment. These include items such as the roll hoop cover, structural front sidepods and the under wing attachment to the tub. Under regulation 14.7.8.16.1, IndyCar's rule book states, 'the… parts may be blended to reduce uneven surfaces and gaps. Hard edges may be tapered or blended. These parts must remain separate parts and there must be a distinct joining line defining each part from its mounting surface or parts.'

The rear attenuator, a vital safety feature, is not permitted any such modification.

Penalty applied

Team Penske initially suspended the key personnel, but later in the week confirmed that IndyCar team president, Tim Cindric, would depart from the organisation, along with IndyCar managing director Ron Ruzewski, and IndyCar general manager Kyle Moyer. This was the second infraction in just over a year after the team's cars were found to have irregularities in their push-to-pass systems ahead of the Indy 500 in 2024.

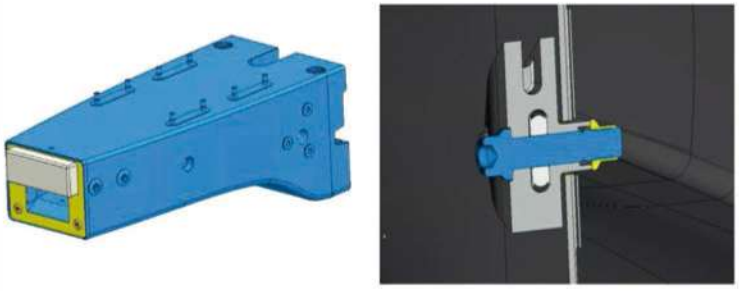
IndyCar president, Doug Boles, was very clear on the matter: breaking rules will not be tolerated, and doing so brings with it a heavy penalty

Scott McLaughlin crashed in qualifying and was not part of the fast 12, while the components on his car were found to be in compliance

'Nothing is more important than the integrity of our sport and our race teams,' said team owner Roger Penske in a statement. 'We have had organisational failures during the last two years and had to make necessary changes. I apologise to our fans, our partners and our organisation for letting them down.'

The team had to make hasty changes to its race team ahead of the '500, and will have to restructure for the remainder of the year.

In 2023, Dallara issued an upddate that the rear attenuator be strengthened



Then, in IndyCar bulletin 14.00, dated 23 May 2023, teams were told to remove the cams from the IR22 rear attenuator and revert to the 2022 version, modifying it for wiring and a replacement bolt

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Opel reveals electric rally concept

Opel has presented a prototype electric rally car based on its popular Mokka model. The Opel Mokka GSE Rally produces 207kW, equivalent to 280bhp, from its electric powertrain, which features a 400V, 54kWh battery. Propulsion is generated by a multi-plate limited slip differential and motorsport-grade gearbox, plus a reinforced driveshaft.

Opel has been running an electric rally series for Corsas since 2021, but says it has developed the Mokka prototype to test its powertrain technology in a competition car.

The Mokka GSE Rally is the first car developed to the requirements of the FIA's eRally5 regulations, although no competitive outings have been confirmed.

It sports a purpose-built rally suspension package from Bilstein, consisting of reinforced MacPherson struts and uni-ball mounts on the front axle. The rear axle, meanwhile, is rigid, with modified springs and dampers.

The vehicle also sports an FIA-certified rollcage and a reinforced underside to protect the powertrain

Opel displayed the Mokka GSE Rally in the service park at the Eindhoven round of the ADAC Opel Electric Rally Cup at the end of May. The series is for Corsas with 100kW (136bhp) electric powertrains, with the motor, inverter and battery taken from the production version. Cars are charged mid-event using electricity from the public medium-voltage grid at 20,000V. A transformer converts the current into 1000V and this is then distributed to individual chargers in the service park. Each car hooks up to a 160kW charging unit that fills a battery to 80 per cent of its capacity in 25 minutes.

The FIA World Rally Championship has thrown its doors open to different powertrain types, including electric, for its regulations refresh starting in 2027. At first, internal combustion engines are set to take priority, but hybrids and full EVs will be welcome later.

Stellantis

Opel has been running an electric rally series since 2021, but the FIA eRally5-compliant Mokka prototype is more powerful than the current Corsas, the manufacturer claiming Rally4 levels of performance

Autonomous league announces season two

The autonomous racecar design competition, Abu Dhabi Racing League (A2RL), will return for its second edition in November.

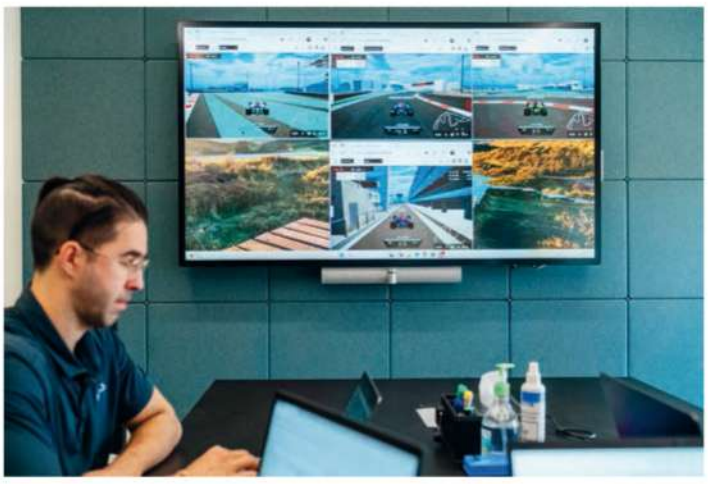
Teams will continue to implement their own AI algorithms on a provided racecar to complete various challenges, including a new sim' sprint. The spec car will be the EAV24, an updated version of the vehicle used in the inaugural 2024 A2RL event, which is based on the Dallara Super Formula SF23 chassis.

According to the series, the car has been 're-engineered to incorporate enhanced sensor arrays, upgraded compute systems and refined control logic, optimised for the demanding conditions of autonomous racing'. The new sim' sprint element involves virtual races, giving teams the chance to test their algorithms in a competitive scenario before unleashing them on the real EAV24.

Plans to open the sim' sprint to those not competing, including fans, are apparently being evaluated.

Last year's A2RL event at Yas Marina Circuit saw Technical University of Münich take the spoils, beating Bremen-based Constructor University by 27.2 seconds in the final six-lap race.

The second edition of A2RL will take place on 15 November, again at Yas Marina.



A2RL

The new A2RL sim' sprint is designed to give teams the chance to run their AI vehicle control algorithms in a competitive scenario before trying them on the real Super Formula chassis

Extreme H tests hydrogen paddock power system

The hydrogen-fuelled charging system that will provide electricity for FIA Extreme H events has undergone its first test.

Like its Extreme E predecessor, Extreme H will hold races in remote environments that require the use of portable units to charge essential facilities. To do this, a system called the Hydrogen Power Unit (HPU2) has been developed by GeoPura.

Each unit generates 500kW of electricity, five times more than the previous HPU1 variant. The system runs on green hydrogen, which is hydrogen gas that has been produced using renewably sourced electricity (ie from wind or solar power) to electrolyse water. Saudi Arabia's Enowa will supply the green hydrogen for the Extreme H chargers.

Where the HPU1 had an integrated battery system, the HPU2 has an external battery. This, according to Extreme H, allows the system to operate either as a standalone generator or with the external battery's support, like a hybrid. Greener Power Solutions is supplying the battery, while overall system integration is being handled by Power Logistics.

Extreme H

Testing of the Extreme H hydrogen charger took place at Siemens in the UK

'HPU2 represents a major leap forward in clean, scalable power,' says GeoPura chief technical officer, Theo Elmer. 'It's lighter, more powerful and more flexible than anything we've built before - designed specifically to deliver in high-demand, high-performance environments like Extreme H. We're proud to be working closely with Power Logistics and Extreme H to show what's possible with hydrogen technology. Together, we're proving that zero-emission power can meet the demands of live motorsport and beyond, and helping accelerate the wider transition away from fossil fuels.'

Extreme H is aiming to become the first hydrogen FIA world championship, although its first event is yet to be announced. A former Extreme E team, Veloce, became the first, and so far only, team to signal its intent to enter the series earlier this year.

SEEN: DEFENDER IN THE DUNES

Defender has completed the first test with its new rally-raid car that will enter the 2026 Dakar Rally. The prototype Defender Dakar D7X-R is powered by a 4.4-litre, twin-turbo V8 and covered mileage in Morocco with 14-time winner, Stéphane Peterhansel, behind the wheel

IN BRIEF

As **Formula 1** rolled into the European leg of its season, it introduced a centralised energy system aimed at reducing carbon emissions from the paddock. The system, developed by Aggreko, includes generators powered by renewable sources such as hydrotreated vegetable oil (HVO), solar panels and batteries. It was trialled at the 2023 Austrian Grand Prix and is now being taken to all nine European races in 2025. F1 says the system delivers a '90 per cent reduction in associated carbon emissions.'

All karts competing in the recent **FIA Karting Academy Trophy** season opener ran with an impact data recorder for the first time. The FIA-developed device, weighing 12g, is aimed at national and regional series as a compact, cost-effective way of recording key data from incidents such as *g* forces.

Prema has started using artificial intelligence (AI) to help its IndyCar engineers with car set-up and race management. The Italian team will use AI to create aerodynamic maps and virtual sensors, as well as analyse variables such as driving styles and track conditions. The AI suite is from Monolith, which also works with the Jota sportscar team.

Eight AI-driven cars from the Indy Autonomous Challenge will take part in a time trial during the IndyCar round at Laguna Seca in late July. Indy Autonomous Challenge CEO, **Paul Mitchell**, said it would bring the industry's AI efforts 'to the doorstep of Silicon Valley.'

Australia's National Trans-Am Series is under new ownership. A syndicate called **HCC**, formed of the initials of three former drivers, has purchased and taken control of the series from **Australian Racing Group**. HCC has also bought the TA2 Muscle Car Series.

A field of 76 cars will contest the **24 Hours of Spa** on 28-29 June, marking a new record for the event's GT era, which started in 2001. A Bronze Cup-class Saintéloc Racing Audi R8 LMS GT3 Evo II set the pace during the official pre-event test in May.

IN BRIEF

The new entry-level racecar from **BMW** is set to contest the Nürburgring 24 Hours in June. The 313bhp BMW M2 Racing was revealed in April and will be available for customers to use in 2026. However, before then, it will be put through its paces in race conditions at the Nordschleife with factory drivers Charles Weerts, Jens Klingmann and Ugo de Wilde at the wheel.

The **FIA European Truck Racing Championship** rolled out a new Goodyear tyre made of 55 per cent sustainable materials at its 2025 season opener. Goodyear says the product includes silica produced from waste rice husk ash and carbon black sourced from 'alternative' feedstocks.

The experimental Genbeta **Formula E** car recently conducted a downhill demonstration run, free-wheeling a 1000m descent of a French alpine road. On its way, it recuperated enough energy from braking to complete a full lap of the Monaco circuit. The target was to regenerate between 1.6-2kWh of energy.

AVL Racetech is developing an updated energy management system in conjunction with the **DS Penske** Formula E team. The Austrian firm is using a virtual model of the current Gen3 Evo car to develop algorithms that determine the best energy harvest and deployment strategies to use during races. The model will be used in the team's simulations.

Electric motor and inverter manufacturer, **Helix**, has appointed Warren Roberts as its new chief operating officer. Roberts was previously managing director of the composites department at Prodrive.

Audi has re-structured its F1 management team less than a year before its 2026 debut. Adam Baker, former CEO of the powertrain division, has departed the company. His position has been terminated and Christian Foyer has been hired as COO. Mattia Binotto now heads up the Audi F1 project, overseeing integration of the chassis, power unit and design centres.

Genesis buys new simulator for LMDh

Genesis Magma Racing

Genesis driver, André Lotterer, said he felt a '1:1 response' from the team's new Dynisma DMG-360XY simulator during a recent test session with it

The Genesis sportscar team has purchased a new driver-in-the-loop simulator for its LMDh project.

The Hyundai brand has opted for a Dynisma DMG-360XY system, which is designed to combine high bandwidth with high stiffness, low latency and high horizontal and ground plane excursion. Genesis will use the system to develop its GMR-001 Hypercar that will debut in the FIA World Endurance Championship next year, prior to joining the IMSA Sportscar Championship in 2027. Genesis-contracted drivers, André Lotterer and Pipo Derani, recently undertook virtual test sessions at Dynisma's base in Bristol, UK. This involved calibrating the simulator to the GMR-001's parameters and setting up a tyre model.

Genesis has not confirmed exactly where the simulator will be housed, although it is most likely to be installed near the Circuit Paul Ricard in southern France. This is where the Genesis Magma Racing workshop is based. It is also the home of ORECA, which is constructing the GMR-001 chassis.

'Access to the simulator gives Genesis Magma Racing's engineers and drivers an important head start in developing the GMR-001 Hypercar, putting us in the best possible position when on-track testing begins later this year,' comments Cyril Abiteboul, president of Hyundai Motorsport.

Bosch launches hydrogen control unit

Bosch Motorsport has launched a new hydrogen powertrain control unit that will make its debut on the H24 EVO experimental prototype.

The Bosch L-HSCU is designed to monitor and control the stored hydrogen that will be used in a fuel cell to power the 650kW (872bhp) demonstrator car. Sensors feed the control unit with data on the pressure and temperature inside the fuel tanks. Hydrogen is stored at -253degC to maintain a liquid state, which offers a higher energy density than gaseous storage. The liquid is then converted into gas for use in the fuel cell system, which generates electricity to propel the car.

Bosch is one of several technical partners in the ACO-backed Mission H24 research project

The control unit monitors the transfer of hydrogen from the tanks to the fuel cell stack and will automatically trigger a safety circuit deployment if any anomalies arise. It also communicates with the on and off-board refuelling systems to ensure the right amount of liquid enters the tanks safely.

In addition to the control unit, Bosch is also supplying the H24 EVO's collision avoidance system, as well as the power box and wiper motor.

In 2023, Bosch unveiled a hydrogen-powered, GT-style car built in collaboration with Ligier Automotive. The Ligier JS2 HR2 will be on display in the 'hydrogen village' at the 24 Hours of Le Mans and is set to complete demonstration laps during the event.

WRC 2027 regulations moving along

New regulations for the FIA World Rally Championship continue to be developed ahead of their planned introduction in 2027.

A notable outcome from recent meetings between the FIA and car manufacturers has been a new chapter to the draft regulations on bodywork. The addition defines the size and shape of volumes, which are designed to be open enough for a wide range of designs to emerge. This is part of the FIA's plan to bring more cars into competition at the sharp end of the WRC, opening the top class to vehicles with more contrasting body styles than today.

The meetings also covered requirements for using sustainable materials in bodywork manufacture, as well as criteria for homologation.

Meanwhile, simulations on crash testing different designs of chassis are ongoing, with real-world crash tests expected to take place this summer.

In the shorter term, the FIA has also confirmed its World Rally Commission is analysing tenders for the supplier of sustainable fuel from 2026 to 2028. The previous supplier, P1 Fuels, stopped providing its 100 per cent sustainable material content solution after three rounds this year due to company financial difficulties. TotalEnergies stepped in for the rest of the 2025 campaign, but the championship wants to return to a multi-year arrangement after that.

The WRC has struggled for entries in its Rally1 class and hopes the new 2027 rules will address that. A core tenet is allowing so-called 'tuners', or independent constructors, to build cars to compete against OEMs

WRT opens state-of-the-art facility in Belgium

W Racing Team (WRT) has opened a new headquarters that will bring its racing and manufacturing activities under one roof. The Belgian squad is one of the most successful in GT racing, having won multiple championships and major races including the 24-hour classics at Spa-Francorchamps and the Nürburgring.

WRT's new base is situated close to Liège Airport, an hour's drive from the Spa circuit. The facility covers 20,475m^2 and will be utilised by 140 employees. The manufacturing side of the business accounts for about 30 per cent of the total staff.

WRT is contracted to build chassis for multiple manufacturers, including Rally2 cars for Hyundai and Citroën, TCR cars for Hyundai and the Toyota GR Supra GT4. It is also working on a hybrid off-roader for the 2026 Dakar Rally and builds cars for the Fun Cup series.

The WRT race team, meanwhile, fields customer BMW M4 GT3s around the world and runs the factory BMW LMDhs in the Hypercar class of the FIA World Endurance Championship. Both the GT and prototype sides of the race team will operate from the new headquarters.

'Reuniting all the WRT motorsport activities in one single location is something that [WRT co-founder] Yves Weerts and myself had in mind for a long time, as we grew constantly over our 15 years of existence, and now it's a reality,' says WRT co-CEO, Vincent Vosse. 'The advantages of having everything and everybody in a single location are immense: we can interact and react better and faster and, like in racing, innovating and improving are crucial.'

The factory was designed by the Aural architectural firm under lead architect, Guillaume Vanwerts. It incorporates various sustainability-driven aspects, such as 70 per cent of the building's energy coming from wind and solar power sources, its 2000 solar panels having a 1.1MW capacity. The facility can also store up to 60,000m³ of rainwater and is set to recycle up to 95 per cent of materials used.

'We have taken up the challenge to be leaders in making motorsport more sustainable with the same passion and determination with which we pursue victory in racing, adds Kathleen Schurmans, co-CEO of WRT.

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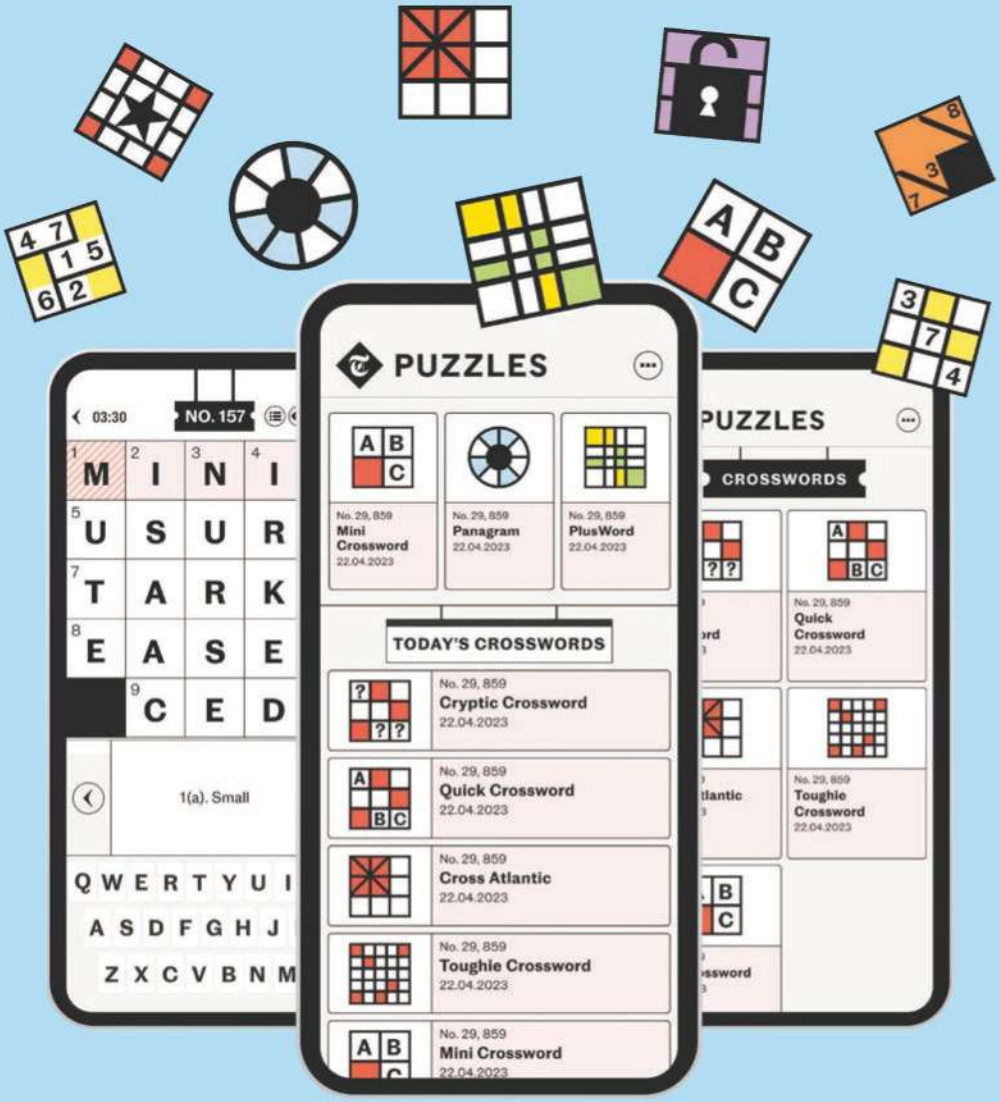

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Stonger together

Challenging times are best overcome by working with others

We have had an unusual start to our 2025 motorsport season. The endless, increasing popularity of Formula 1 is matched by the struggles in the FIA World Rally Championship. IMSA and Le Mans look stronger than ever, with many OEM brands competing, and NASCAR is resolving some of its difficulties.

The UK supply chain for these series has had to move fast to meet challenges from unexpected US tariff increases. At time of writing, these remain confused and, if not resolved, they will severely damage future exports to the US.

To that end, the MIA has been involved in many discussions with wider industry and the UK government to clarify and identify the best way forward for our members.

In May, we are taking a motorsport business delegation to Charlotte, North Carolina, supported by the UK's Department for Business and Trade, to meet potential customers and explore opportunities.

The US does not export many motorsport supplies to the UK, so our 'balance of trade', in the eyes of its current president, is unbalanced. However, all major American series import components and hi-tech solutions from the UK and Europe, and the cost of these will rise. So, rather than improving the balance of trade, the president's 'success story' of tariffs will simply increase costs for teams competing in the US. Unfortunately, it seems that British motorsport will also see costs rise, due to increases in shipping, fuel and travel.

Reap the rewards

Despite these challenges, major series continue to increase in popularity, so rewarding their teams, sponsors and partners. Formula 1 remains the outstanding leader of the pack, having generated $3.4bn in revenues in 2024, and attracting some 750 million fans. Its most ambitious and challenging calendar ever sees 24 grand prix weekends this year. This popularity is welcome, but really tests suppliers, teams and the circuits that hosted 6.5 million live fans last year.

The UK should be proud that Liberty Media chose to operate this complex global sports project on its turf, and that the most popular F1 grand prix will be at Silverstone again.

Motorsport Valley is home to the majority of F1 teams, including the new Cadillac outfit. Meanwhile, the Audi project is creating a very welcome new technology centre here over the next few months. All these internationally recognised activities bring increased business into the UK and, most importantly, attract other technology-based investments and highly qualified people.

The MIA will shortly be sharing the results of our industry-wide business survey. Over recent years, employee numbers have risen considerably, as have revenues and investments. It shows motorsport is a success story for the UK; a truly modern industry linking engineering to entertainment with even more potential ahead.

British teams and suppliers dominate F1, but are also prevalent in the US, so understanding how recent tariff changes affect them is a high priority

A new generation will now enjoy high-speed entertainment with close competition and cars built using the latest technology and engineering.

I recently welcomed students from Japan, the US, Sweden and India, as well as the UK, at the MIA School of Race Engineering. These bright, young minds have been attracted by the power and excitement of motorsport, F1 in particular, and the cocktail of engineering, technology and entertainment it offers. The school has so far attracted students from over 34 countries, all tutored by current, successful UK-based race engineers. They leave the school understanding their future in motorsport and well prepared to build their success. Naturally, we hope many of them will be based in Motorsport Valley, adding strength to the UK's international reputation.

I hope the UK government will make more of this reputation of British motorsport engineering and technology. Teams and businesses based here attract the best minds in the world, adding continuously to our pool of outstanding technologists. This, in turn, attracts inward investment and builds international connections, all strengthening Motorsport Valley, where we work with the government to build an ever-stronger business community.

The MIA has just completed fascinating, detailed research for the UK government. The first conference we held on energy efficient motorsport (EEMS) was 23 years ago now. These years of knowledge-gathering and product development are all aimed at using our available energy sources more efficiently to race. Many developments have emerged recently from our experienced community, whose unique and valuable subject knowledge means motorsport continues to be at the forefront of mobility-based energy efficiency.

Success stories

Our research identified a number of motorsport businesses which developed and delivered solutions based on the efficient use of energy. These success stories from across Motorsport Valley will secure a valuable future for the UK in these technologies. The journey from motorsport to net zero has created an exciting, successful and relevant path for our business community over the next decade, when such expertise and knowledge will become increasingly important.

Please keep your eye on our website (www.the-mia.com) for details of activities focused on energy efficiency and building international trade. Challenging times are best overcome by working with others in this business community. The MIA has grown strong over 30 years based on this ethos, proudly owned by the industry and developed to benefit it.

Motorsport Valley is a registered trademark of the Motorsport Industry Association, owned by its members on behalf of the wider UK industry. Chris Aylett is CEO of the MIA (www.the-mia.com).

The journey from motorsport to net zero has created an exciting, successful and relevant path for our business community over the next decade

Racecar engineering
Inside the world of modern motorsport technology

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Subscription rates
UK (12 issues) £84
Europe (12 issues) £100/€120
ROW (12 issues) £120/USD$165
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Racecar Engineering (ISSN No: 0961-1096, USPS No: 463) is published monthly by The Chelsea Magazine Company Limited, and distributed in the USA by Asendia USA, 701 Ashland Ave, Folcroft PA. POSTMASTER: send address changes to Racecar Engineering, 701 Ashland Ave, Folcroft, PA. 19032.

Printed by Walstead Roche Ltd
Printed in England
ISSN No 0961-1096
USPS No 007-969

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TELEGRAPH MEDIA GROUP

www.racecar-engineering.com

Coalition of the winning

The WEC is stronger than ever, but there are still clouds on the horizon

This year's 24 Hours of Le Mans sees eight manufacturers competing in the top Hypercar class, with a further three in LMGT3. And there are more coming. Genesis is confirmed to arrive in 2026, while Ford and McLaren will supplement their GT3 programmes with Hypercars in 2027. Never before have so many manufacturers had long-term projects in endurance racing, and so it makes sense for them all to sit together and work out what they need to do to keep it that way.

The reason for this proliferation of manufacturer interest is simple. Balance of Performance is the key element that allowed race teams to approach their boards of directors and promise they had a chance of winning. It helps that budgets are relatively low in comparison with other race series (and likely previous race programmes), while the return on investment (ROI) is starting to climb. Le Mans is still the daddy, the one that makes money in terms of media ROI, though others are improving, too. The 6 Hours of Spa-Francorchamps, for example, attracted nearly 100,000 spectators this year over the course of the weekend in May, unthinkable numbers at the start of the WEC in 2012.

There are a few issues for the OEMs to iron out, namely the rules. The top tier in the WEC has both LMH and LMDh cars. Combined they form the Hypercar class, but in IMSA the equivalent class is called GTP. It is mostly made up of LMDh cars and utilises a different BoP.

Never before have so many manufacturers had long-term projects in endurance racing

Manufacturers were called together at the start of the season to work out what they need to do to keep everyone in the competition. The plan is to agree the boundaries and present them to the rule makers. Ferrari famously wants to design its own chassis, which it does, and that design is built by Dallara. Toyota has to retain its hybrid system, as the programme is paid for by the likes of Denso, which supplies the hybrid motor and inverter. Meanwhile, Porsche and BMW need to keep their interests going on both sides of the Atlantic, in WEC and IMSA, at least for this year, to keep their options open in case budgets are cut for 2026.

One major complication of the new rules was a plan to base the next generation of LMP2 cars on the current LMDh chassis. However, the ACO dropped that plan at Le Mans last year, instead launching a new LMP2 chassis and powertrain tender process which closed in May 2025. With the link now broken, it's easier for the manufacturers to settle their technical differences in the regulations and do what was originally intended – create a global platform.

Other changes, such as the switch from the Sauber wind tunnel in Switzerland to Windshear in the US, although expensive for those used to the European road trip, means at least there is now a single reference tunnel, for both Hypercar and GTP class cars.

A sole tyre supplier, a BoP system and increasing awareness of the series against a weak opposition (see FIA World Rally, international-level touring cars and Formula E) and the future for endurance racing looks bright.

There is, however, a cloud on the horizon, as there always is. The WEC is wedded to the GT3 formula, and that provides great racing. Seeing the prototypes weave their way through traffic adds to the spectacle, as well as providing a place for Bronze and Silver-graded drivers to race, now that LMP2 has been dropped as a full-time class. Yet with organisers around the world now wanting to put their own mark on their series, GT3 is becoming unnecessarily complicated. Different levels of data analysis, alternative sporting regulations and various fuels, power and aero levels are all putting the category under threat. Just as the prototypes are looking to unite worldwide, the global GT3 entity is in danger of splitting up.

It can, of course, be brought back together, and there is a global will to do so. GT3 is one of the most successful rule sets ever created in racing. It caters to all levels of driver, it is prolific and versatile. It has led to successful customer racing divisions for manufacturers and for customers, who can compete in some of the biggest endurance races in the world. Yet, with budgets of north of €5m ($5.6m) to run in WEC LMGT3, compared to less than €2m ($2.3m) in GT World Challenge Europe, there is a clear disparity.

Another cloud on the horizon is the future of hydrogen in racing. The ACO still plans to tear down its pit building and create hydrogen storage beneath it, at least for some of the cars when they do finally get to race, but the idea that in the early 2030s all competitors, including GT3 cars, will be using hydrogen looks increasingly ambitious. Toyota, Ferrari and Alpine are all still at the table to help thrash out technical rules for the hydrogen Hypercar category, and the will is still there to create a viable and sustainable future. Whether or not the fuel becomes the dominant energy source in the 24 Hours of Le Mans remains to be seen.

ANDREW COTTON Editor

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